TP 5314E

CONVERSION OF DIESEL ENGINES TO DUAL FUEL (PROPANE/DIESEL) OPERATION

by

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Calgary, Alberta

February 1984

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17. Abstract

The objective of this research project was the development and evaluation of a device to convert a diesel engine to dual fuel (propane/diesel) operation. A turbo-charged 250 HP diesel engine was directly coupled to a dynamometer under laboratory conditions with appropriate instrumentation. The engine was operated at speeds between 500 and 2500 RPM, and at various torque levels at each speed. At each RPM/torque point the engine first operated on diesel oil alone, and then increasing quantities of propane were induced into the air intake until detonation occurred.

The results indicate that the proportion of propane that can safely be induced into a diesel engine varies considerably with RPM and torque so that a sophisticated metering system would be required to maximize diesel oil displacement by propane.

The price differential between propane and diesel oil is not sufficient to make the conversion to a dual fuel (diesel/propane) mode cost effective at 1983 price levels.

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17. Résumé

Cette recherche avait pour objectifs la mise au point et l'évaluation d'un dispositif permettant la conversion des moteurs diesel en moteurs mixtes pouvant brûler un mélange de propane et de carburant diesel. Pour cela, un moteur diesel de 250 hp à turbocompresseur a été monté en prise directe sur un banc d'essai dynamométrique doté de tous les instruments de mesure nécessaires pout l'évaluation en laboratoire envisagée. Le mode opératoire des essais prévoyait de faire tourner le moteur à des vitesses allant de 500 à 2500 tr/min tout en faisant varier la charge du moteur. Ceci pour déterminer les caractéristiques de fonctionnement du moteur à chacun des points des courbes régime/couple, moteur alimenté d'abord en carburant diesel uniquement puis par un mélange propane/diesel à teneur en propane allant jusqu'à la limite de détonation.

Les résultats montrent que la proportion de propane utilisable sans compromettre le fonctionnement sûr et efficace du moteur varie considérablement selon le régime et la charge de celui-ci,et que, pour maximiser le remplacement du diesel par le propane, il est nécessaire de mettre au point un appareil doseur de haute technicité. Or, l'écart entre les prix du carburant diesel et du propane est trop mince pour faire de la conversion envisagée un choix économiquement justifiable en 1983.

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3. McMullen Construction Ltd, Didsbury, Alberta - for their offer to permit the conversion of a Diesel Power unit to dual fuel.

FORWARD

Suburban Propane Products Ltd. were involved in the retail sales of propane, propane appliances, and operated a propane conversion center. The principals of this Company were W.J. Morgan, President, and his brother, D.B. Morgan. They disposed of the Company in early 1980 and then formed a Company known as Space Fuel Gas Products Ltd. This latter Company became a wholesale distributor in Western Canada of an integrated line of propane carburetion equipment.

During the years the brothers were involved in the retail propane carburetion business, they developed and patented a device used for the induction of propane into the diesel engine over the road vehicle. They converted several vehicles to their system during 1979 and 1980. It was discovered however that the system needed perfection and research was needed.

It was late in 1980 that Space Fuel Gas Products Ltd. made an unsolicited application to Transportation Development Centre for a grant to further research and develop the induction system. It was at this time the Canadian Government recognized the apparent shortfall of petroleum products produced in Canada, especially those products such as gasoline and diesel fuel that are derived from the refining of crude oil. Crude oil reserves are a non-renewable resource that were rapidly being depleted.

Canada was not, and still is not, self sufficient in these crude oil supplies. The Canadian Government then recognizing these depleting reserves, was vitally interested in finding alternative fuel sources. One of these being propane which was, and is, in abundant supply in Canada.

The Canadian Government was therefore interested in the conservation of Canadian crude oil and proceeded to develop a contract with Space Fuel Gas Products Ltd. to fund the further research and development of the propane induction system into diesel engines, as per the unsolicited application made by Space Fuel Gas Products Ltd.

Space Fuel Gas Products Ltd. entered into a Contract with D.S.S. to further develop the use of propane in the diesel engine as dual fuel operation (Propane/Diesel). The Contract was amended during the period the project was in progress. The Contract terminated on February 29, 1984.

By the incorporation of Space Fuel Gas Products Ltd. the Company acquired a substantial wealth of propane expertise and experience. W.J. Morgan, President, 25 years of administrative and marketing experience. D.B. Morgan, Technician, 25 years of technical and marketing experience. S.W. Pepper (Retired), Vice President, 33 years of adminstrative and technical experience. G.T.Hefter,(Retired), 30 years of administrative and marketing experience.

FORWARD (continued)

Thus, Transportation Development Centre (TDC) and Space Fuel Gas Products Ltd. had some 113 combined years of experience and expertise to draw on for this research program.

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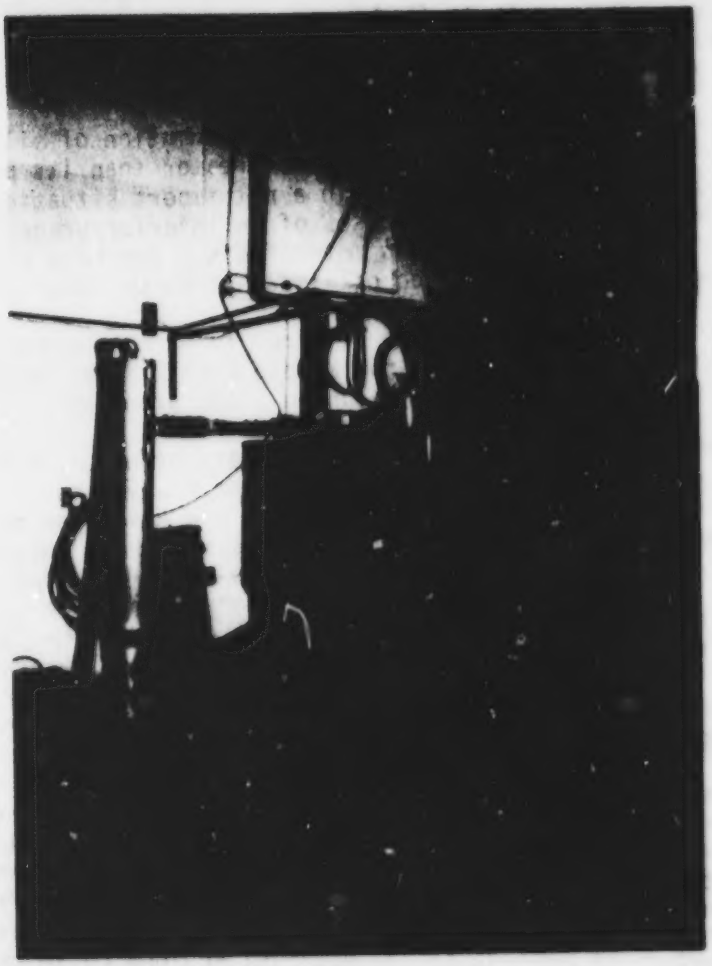


DUAL FUELED DIESEL ENGINE

1. INTRODUCTION

1.1 Program Objectives

Canada has large reserves of crude oil in place, and is continuing its program to find new sources of crude, both conventional and synthetic. This program is designed to make Canada self sufficient in oil by 1990.

In the meantime Canada's present consumption of oil exceeds 900,000 barrels (143,000 m^3) per day which is greater than its production by about 20%; this means Canada is in a net import situation. This imported oil is expensive and in some cases of an inferior grade, unsuitable for high performance specification motor fuels. The rate of growth of Canada's consumption of crude oil is about 4% per year.

The availability of crude oil from foreign sources is subject to many uncertainties, such as, the Middle East crisis, unstable world prices, shipping problems, unbalanced trade problems.

These problems have led Canada to seek other alternatives to alleviate this situation and to reduce the heavy demands for crude oil. The Canadian Department of Energy, Mines and Resources have developed several grant programs since 1980 to conserve these unrenewable resources. Some of these programs include the grants payable to operators of gasoline powered vehicles who converted their vehicles to run on straight propane or natural gas. Other grants are provided for dual fuel operations such as diesel/propane and natural gas/gasoline. It is hoped that these alternative forms of energy will significantly reduce, or even reverse the annual demand rate in the consumption of petroleum products produced from crude for transportation use in Canada.

Diesel fuel is a major and growing component of Canada's transport fuel mix (19.3% in 1979) accounting for approximately 151,000 barrels (24,000 m^3) per day. The aim of this research program was the development of a system for converting diesel engines to dual fuel (Propane/Diesel) operation. Preliminary experimentation had indicated that as much as 30% of the diesel fuel consumed in diesel engines could be displaced with propane, accompanied by an improvement in fuel efficiency, engine maintenance, and an overall reduction in emission levels.

Dual fuel operations of both transportation and stationary applications would then project a saving of approximately 90,000 barrels (14,300 m^3) per day of diesel fuel in dual fuel operations by the year 1990.

It was with these facts in mind and the need to reduce the Canadian demand on crude oil that TDC recognized that a solution to this problem required immediate attention.

This project resulted from an unsolicited proposal from Space Fuel Gas Products Ltd. It is consistent with the National Energy Program for Canada which seeks to eliminate all imports by 1990. It also calls for zero growth in use of oil based transportation fuels over the next decade.

1.1.1 Project Sponsorship

This project was sponsored by TDC and Space Fuel Gas Products Ltd., the latter contributing approximately 10% of the funding and all of the expertise.

1.2 Background Data

Over the past number of years there have been a number of systems developed for the injection of propane into diesel engines. Most of these were designed to increase power and not to displace diesel fuel. None of these devices has been completely satisfactory and most have now fallen by the way. There are still some on the market and some were tested in this research project; the results are tabulated.

During the years that D. Morgan has been involved in the propane business as a marketer and technician, he became involved with some of the systems that were used as power boosters on diesel engines. Although Mr. Morgan and his Company were primarily interested in using any device or appliance that would develop propane sales, he was still interested in a system that would replace diesel without increasing horsepower. (Increasing horsepower by the addition of any substitute fuel has created warranty problems with diesel engine manufacturers).

Mr. Morgan therefore began to experiment with a propane induction system in early 1979 and applied for a patent for his invention in 1980. He had experimented with this induction system on several over the road transports. It was apparent from these early experiments that a great deal of research and improvement was needed. Therefore, when Space Fuel Gas Products Ltd. was formed and D. Morgan became a principal of that Company, he brought with him his invention and expertise. It was at this point that Space Fuel made an unsolicited application to TDC to research and develop this induction system.

Space Fuel Gas Products Ltd. is a wholesale marketer of propane carburetion equipment, therefore their interests in the development of this induction system was twofold.

1. The National Energy Program for Canada could meet some of its objectives by sponsoring a research program aimed at reducing diesel fuel consumption.

2. That Space Fuel Gas Products Ltd. could perfect an invention that they could readily market and satisfy the objectives of this program.

1.3 Propane as a Motor Fuel

1.3.1 What is Propane

Propane is a hydrocarbon gas - its chemical formula being C_3H_8. Its normal state is a gas under most atmospheric temperatures and pressures encountered. It is stored and transported as a medium pressure liquid.

When liquid is released to the atmosphere it expands 270 times its liquid volume. Propane gas can be liquified by reducing its temperature to -44° F (-42° C), which is its boiling point, or by compression. Pressure and temperature are always relevant, at -44°F (-42°C) there is no vapor pressure and the gas remains a liquid. At 100°F the gas is compressed to a liquid at 205 p.s.i.g.

1.3.2 Characteristics

Boiling Point	-	-44° F (-42°C)
Weight of liquid per Imp. gal	-	5.10 lbs (2.3 Kg)
Cu. Ft. of vapor per Imp. gal	-	44.3 cu. ft. (1.25 m^3)
Cu. Ft. of vapor per lb.	-	8.6 cu. ft. (0.24 m^3)
BTUs per Imp. gal	-	110,000 BTU (116.6 MJ)
BTUs per cu. ft.	-	2,520 BTU (2670 kJ)
Cu. Ft. of air to burn one cu. ft. of gas at atmospheric pressure @ 60°F	-	23.82 cu. ft. air
Specific Gravity of vapor	-	1.5
Flammability limits in air		
Lower %	-	2.37
Higher %	-	9.50
Octane Rating	-	110 plus
Grade A.P.I.	-	HD.5

It is important to understand these characteristics as they do have considerable bearing on knowing how to properly and safely handle propane in its various applications.

1.3.3 Source

In Canada 80% of all propane gas is processed from natural gas. Natural gas as it comes out of the earth's formation cannot be utilized or transported by pipeline to end users without being first processed. This includes the removal of all corrosive materials such as hydrogen sulfide (sulphur) and the removal of a certain quantity of hydrocarbons so as to meet a pipeline specification and a utility specification. This provides the natural gas consumer with a uniform product (i.e., 1000 BTU (1.06 MJ) natural gas).

Twenty percent (20%) of Canadian propane production comes from certain refinery processing such as at Sarnia, Ontario, or at refineries in Vancouver, B.C. Recent National Energy Board figures indicate that there is over 70 Trillion cu. ft. (2.0 Gm^3) of proven natural gas reserves in Canada and exploration continues daily for more reserves; likely by the time this report goes to print these numbers will be obsolete. It is therefore evident that this resource will make it possible to assist the Board in meeting some of its self sufficiency oil production goals by 1990. The Propane Gas Association of Canada in its Propane Supply Report of August 3, 1983 reports the following numbers.

"Individual forecasts through 1986 are shown for 164 gas processing plants. It is interesting to note the growth in the number of these plants in recent years illustrated in the following tabulation.

Gas Processing Plants in Canada as of December 31, 1979	-	96
New gas plants in 1980	-	14
New gas plants in 1981	-	15
New gas plants in 1982	-	18
Gas processing plants in Canada as at December 31, 1982		143
New gas plants 1983 (known as at July 31)	-	12
Committed gas plants 1984-85	-	4
Prospective new gas plants	-	5
Total		164

Actual and Forecast Extraction of Propane at Gas Processing Plants in Canada in Thousands of Cubic Metres

Actual			Forecast		
1981	1982	1983	1984	1985	1986
5833.6	5823.8	5673.0	6180.4	6577.6	6947.7

Actual and Forecast Production of Propane at Refineries in Canada by Region in Thousands of Cubic Meters

	Actual		Forecast			
	1981	1982	1983	1984	1985	1986
Atlantic Provs.	105.5	84.9	80.0	85.0	90.0	95.0
Quebec	292.9	262.8	205.0	120.0	120.0	120.0
Ontario	492.7	278.1	290.0	315.0	215.0	475.0
Man. & Sask.	52.7	43.6	30.0	30.0	30.0	30.0
Alberta	293.2	257.0	340.0	340.0	365.0	375.0
B.C.	129.1	135.4	145.0	145.0	145.0	145.0
Total	1367.1	1161.8	1145.0	1255.0	1335.0	1360.0
Combined	7194.7	6985.6	6818.0	7435.4	7912.6	8307.7 "

The foregoing figures bear out the fact that there is a large supply of propane available in Canada. This will assure customers of an alternate fuel, a supply for years to come.

1.3.4 Availability

Propane is transported from source to market in various ways.

a) Pipeline from gas well to gas plants
b) Product pipeline from Gas Plants to market areas
c) Large jumbo tank cars haul from source to market areas
d) Large semi trailer transports from distributor and Gas Plants to dealers and industrial markets
e) Smaller bobtail trucks from dealer to consumer

To compensate for peak and dip demand loads, large underground salt dome storage, levels out the transportation and production problems. Large above ground storage tanks provide assurance of supplies at the dealer level.

There are approximately 3000 retail propane filling stations in Canada. These are growing at an ever increasing rate due to the tremendous growth in the conversion of gasoline operated vehicles to propane in Canada (approximately 17,000 conversions per year). These facilities will assure the transport operator that adequate refilling facilities exist all across Canada.

1.4 Program Administration

The scientific authority for the program was the TDC. It was responsible for all matters concerning the scientific and technological content of the work under the Contract.

A project officer from TDC was appointed to manage the project and to approve the work plan and any modifications made to it. The Contract and/or modifications were issued by the Department of Supply and Services (D.S.S.). The Science Procurement Manager was responsible for the management of the Contract.

A detailed statement of work was prepared by TDC which included all activities under the terms of the Contract.

Space Fuel Gas Products Ltd. contributed approximately 10% of the project funding plus the overhead costs. Space Fuel provided a Program Manager and secretarial service. All other operations personnel were hired specifically to carry out the program. Some were maintained on a full time basis while others were hired only on a part time basis. The workload and reporting procedures were divided between those directly involved in the project.

The Program Manager (a Space Fuel Gas Products Ltd. employee) negotiated the Contract and amendments with DSS and TDC. He was responsible for hiring the project personnel and directing the program activities. He prepared all monthly monetary claims for submission to DSS and prepared monthly cash flow statements so that a close examination could be kept on budgets and expenditures for each account; he was also responsible for the preparation of the final report and its submission to TDC.

The Technical Manager was hired specifically for the project on a full time basis. A mechanical engineer, he was responsible for the proper selection of all equipment to be used in the research program and for setting this equipment up.

The Technical Manager was responsible directly to the Program Manager for all shop, laboratory and field test operations. He was responsible for following through on the detailed work schedules. He prepared monthly technical progress reports for the Scientific Authority Officer and prepared in detail all technical data for the final report.

He had as his Assistants, two technicians, one full time and one part time. The full time technician was a fully licensed diesel mechanic who operated the test equipment. The second technician was known as Technician No. 2 and was a part time employee. He was a licensed and qualified propane service and carburetion technician who did most of the propane induction system development.

Space Fuel Gas Products Ltd. provided the administrative facilities.

The laboratory and shop facilities were provided by TDC in a separate building where all research and development activities were carried out.

1.5 Program Activities

In order to address the specific program objectives in a rational manner the task and work elements were defined in eight groups of activities as follows.

a) Project Planning. This involved a meeting of all those personnel involved in the project; to plan the material requirements, facility requirements, equipment requirements and to fit these into a timetable that would satisfy the Contract costs and time schedule.

   A budget by months and total was prepared together with a detailed program of work to be accomplished.

b) Pre Engine Testing Program. This involved obtaining a facility which would house the laboratory, engine and dynamometer, and an office facility for the technical personnel. Then there was the construction of test benches and certain lab. equipment that would be required before any engine testing could be done. It required the purchase of materials and machinery to develop the actual induction system.

c) Selection of Suitable Testing Equipment. This activity involved the selection of a diesel engine of 250 HP, a dynamometer and a cooling system for both the engine and dynamometer. All of the instrumentation required to perform all of the tests and metering devices to measure the consumption of both diesel and propane fuels.

   Initially we had thought that the major components such as the engine and dynamometer could be rented. After exhaustive efforts it was found that equipment suppliers were not willing to rent such equipment for research purposes.

It was found that it would be necessary to purchase equipment if we were to proceed with the program. The problem now being that the Contract budget did not allow for the cost of purchasing this equipment. It therefore became necessary to request revisions to the Contract to accommodate the purchase of the needed equipment. Unfortunately, several months were lost in this process.

d) Installation of Equipment. After purchasing the necessary equipment and instrumentation for the engine testing; there was the chore of installation. This was done mostly by our own technical personnel. Contractors were hired to do floor reinforcement for the engine mounting, to install the exhaust system through the roof, electrical hook-ups, etc. There was also the necessity for soundproofing the engine room due to noise levels affecting adjoining tenants. This was done by placing shock absorbers under the engine mounts and exhaust silencing. All Workman Compensation rules were strictly adhered to for the engine and dynamometer operation.

Very rigid regulations governed the installation of propane storage in this industrial area. Time was lost in obtaining approvals from the City and Provincial authorities. There were limitations on storage capacity, location of storage and protective requirements that all had to be resolved.

e) Running in of Equipment prior to Operating Tests. Once all the equipment was installed, it was necessary to check all components for proper operation. All pre-engine operating tests were done with diesel fuel only. Each individual piece of instrumentation was tested and calibrated; in some instances outside engineering expertise was hired to satisfy ourselves as to the accuracy of all recording and metering devices. This prerun-in period eliminated many corrections that may have been required after actual engine operating tests began.

Up to this point, practically a year had passed without any dual fuel engine operation tests being performed.

f) Operating Testing. The actual engine operating testing now commenced. The body of this report will describe in detail these results. The general testing theory was to operate the engine at various RPM and torque on diesel fuel only, and then duplicate these procedures by adding different percentages of propane without increasing horsepower, but rather to meet the objective by the replacement of diesel fuel with propane.

g) Field Testing. During program planning, we had contacted several small and major trucking firms plus firms with large stationary engines (400HP) to advise them of our program to induce propane into diesel fueled engines (propane/diesel operation). We asked if they would consider allowing us to install an induction system on one or more of their truck units after we had successfully completed our own laboratory engine testing. We received satisfactory acknowledgments from ten of these firms of their willingness to cooperate with us, if and when we had successfully completed our lab. engine tests.

Due to delays in our program and several major equipment failures, the contract was coming near to its end and the winter of 1983 was well upon us. This meant that field tests would have to be done under critical winter weather conditions and under a very limited time schedule. Field tests were originally planned to last over a period of 3 months and we were now down to having only a month left under critical conditions.

We did however contact many of these people who had acknowledged our previous request to use one or more of their truck units for field testing. None were readily prepared to proceed with us for two reasons:

1. Some dual fuel (propane/diesel) systems had been promoted during the previous two years. Reports of engine failures attributed to these systems were widespread.

2. No one wanted to proceed with a test unit unless we were prepared to indemnify them for any engine failures that could be attributed directly to the induction of propane into the diesel engine. We, of course, were unable to commit ourselves to this liability.

As a result of the foregoing we did not proceed with any field testing.

h) Final Report. The Program Manager and Technical Manager assembled the material for this final report and wrote up the text.

2. LABORATORY TESTS

2.1 Equipment Tested

2.1.1 Engine

The engine used in the laboratory tests was an International Harvester Model 573 B. Its description is as follows:

- Turbo charged V-8. Intake manifold pressure of 17-21 psig at a stall speed of 1900-2100 RPM.
- Rating, 260 HP @ 2500 RPM
- Open combustion chamber design
- Maximum air cleaner restriction allowable - 25 inches of water

2.1.2 Propane Induction Equipment

Four different systems of propane induction were tested. Usual practice was to draw propane vapor from a propane tank located outside the building. A few tests were run drawing liquid propane (vaporizer needed) from a 30 pound tank.

Three of the systems used a vaporizer to regulate the propane pressure. A negative pressure of ½ inch of water was required across the vaporizers secondary pressure diaphram in order to draw propane out of it. This meant that a pressure drop was required in the engine's air supply system before propane would be drawn into it. The primary vaporizer used was an LPF model T, although an Impco Model J was used for two tests (both vaporizers used an orange spring). The three systems were as follows:

- Metering Tubes. These consisted of ½ inch diameter copper tubes about 4½" long. Three of them had their ends capped and holes were drilled in a straight line along their axis (they were numbered as follows: number of holes drilled - number of drill used to drill holes). The capped-end tubes tested were 3-36, 5-36 & 9-36. The fourth tube tested had an open end (cut at 45° to its axis). These metering tubes were installed (in turn) in an air supply tube (5 inch diameter) situated just ahead of the inlet to the turbo compressor.

Photo 1 Metering Tubes

- Y'd Carburetor. This system consisted of a carburetor whose outlet (propane-air mixture) was Y connected into the engine's main air supply. Two carburetors were used; an Impco Model 425 and a Holley 2 Barrel Model 902

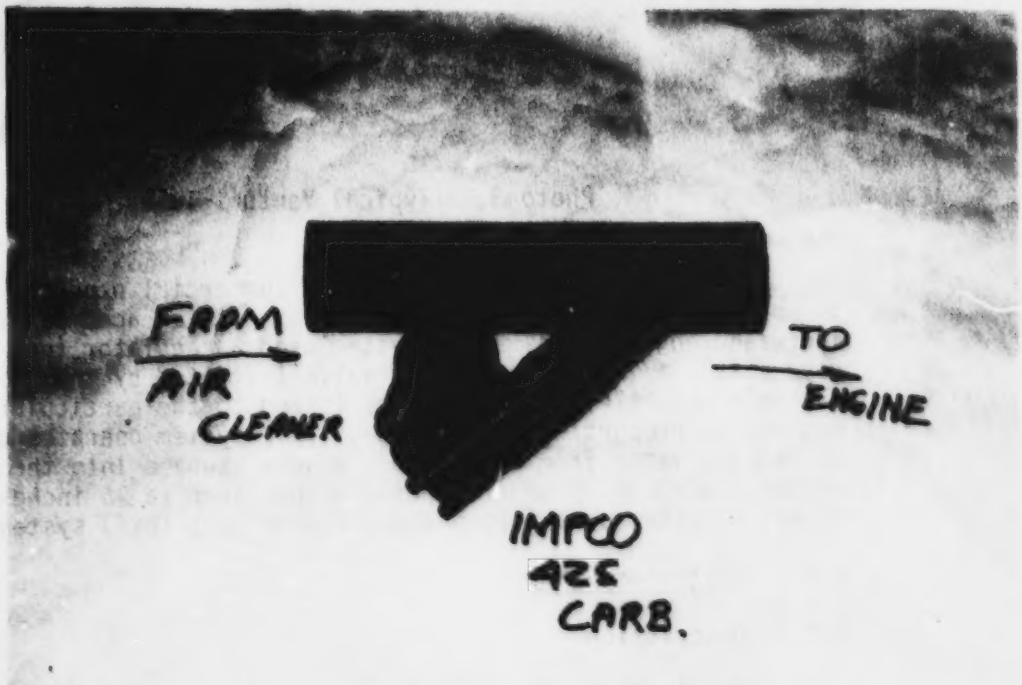


Photo 2 Y'd Carburetor Set-up

- Venturi Induction Tubes. The venturis were installed directly in the engine's main air supply by replacing a section of the 5 inch diameter tubing from the air cleaner. The venturis were numbered as follows; Diameter in inches of engine's main air supply X diameter in inches at venturi throat. Two venturis were tested: a 5 X 4 and a 5 X 3.

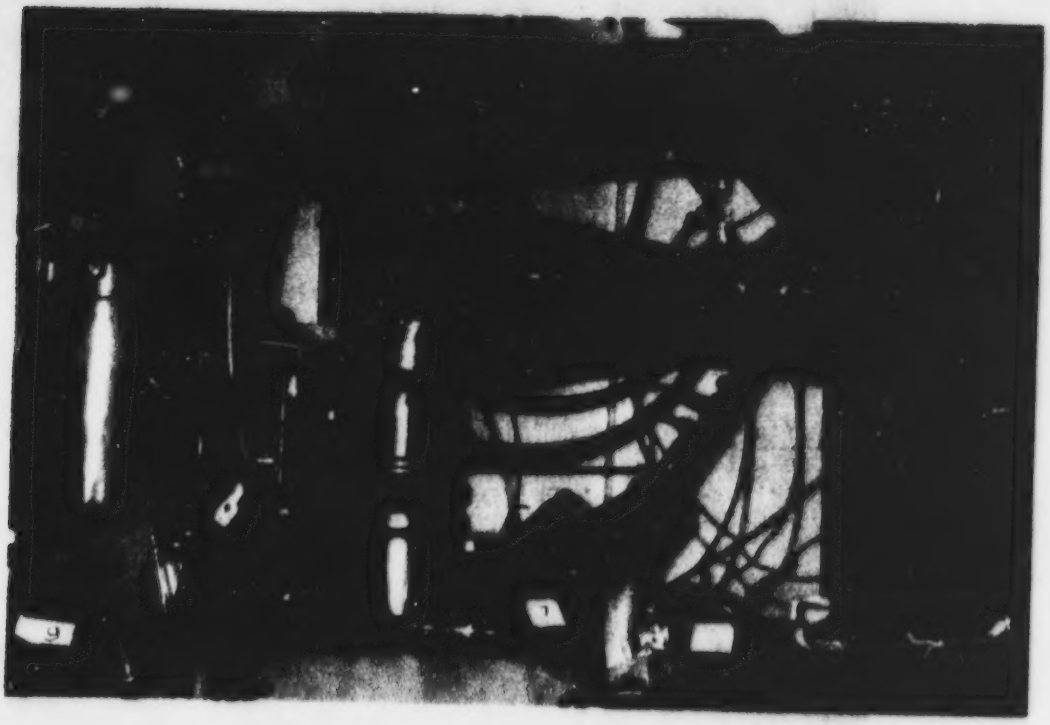


Photo 3 Typical Venturi Tube

- Daisey Diesel Booster. This is a commercial product that is sold more as a horsepower (hp) boost with an accompanying increased engine life. This system used a regulator (not a vaporizer), a variable metering valve (actuated by the engine"s throttle) and an orifice (sized to the particular engine) to proportion the propane. This system operates only on propane vapor from a tank and inducts propane into the engine's air supply under a positive pressure (a 15 inches of water system or a 5 pounds per square inch (psi) system.

2.2 Instrumentation

2.2.1 Description

See Appendix for a list and description of the instrumentation used in this research project

2.2.2 Test Set Up

The instrumentation has been broken down into seven broad areas of measurement:

1. Diesel fuel consumption
2. Propane Consumption
3. Engine horsepower (H.P.)
4. Engine cylinder pressure
5. Engine temperatures
6. Engine exhaust smoke
7. Ambient conditions

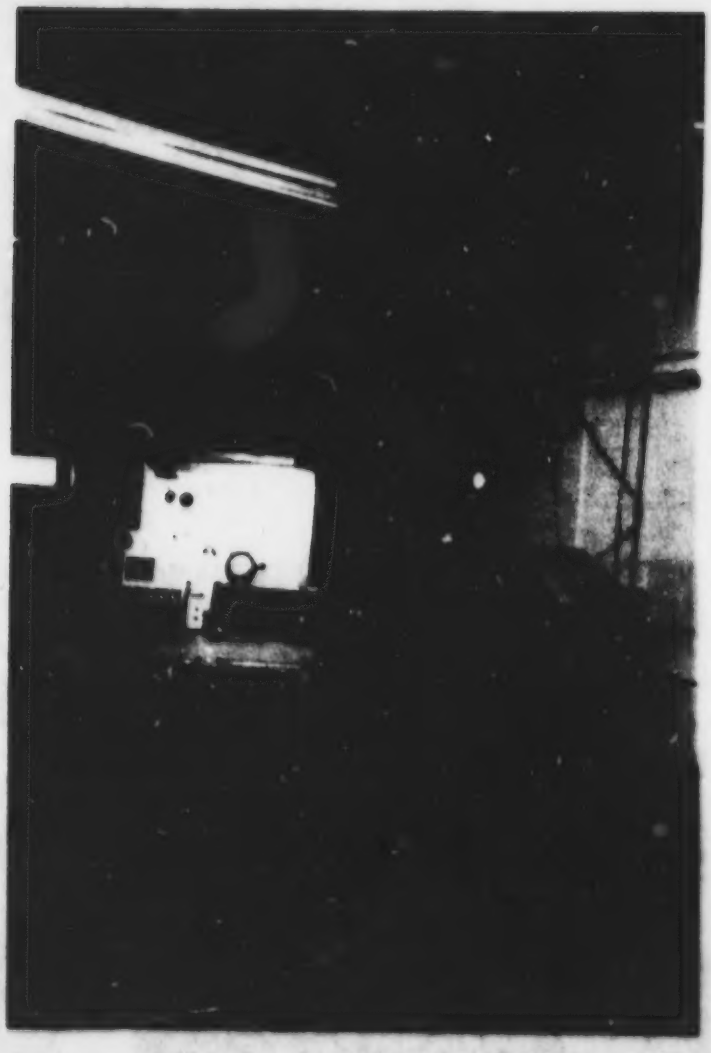


Photo 4 General view of Test Set Up

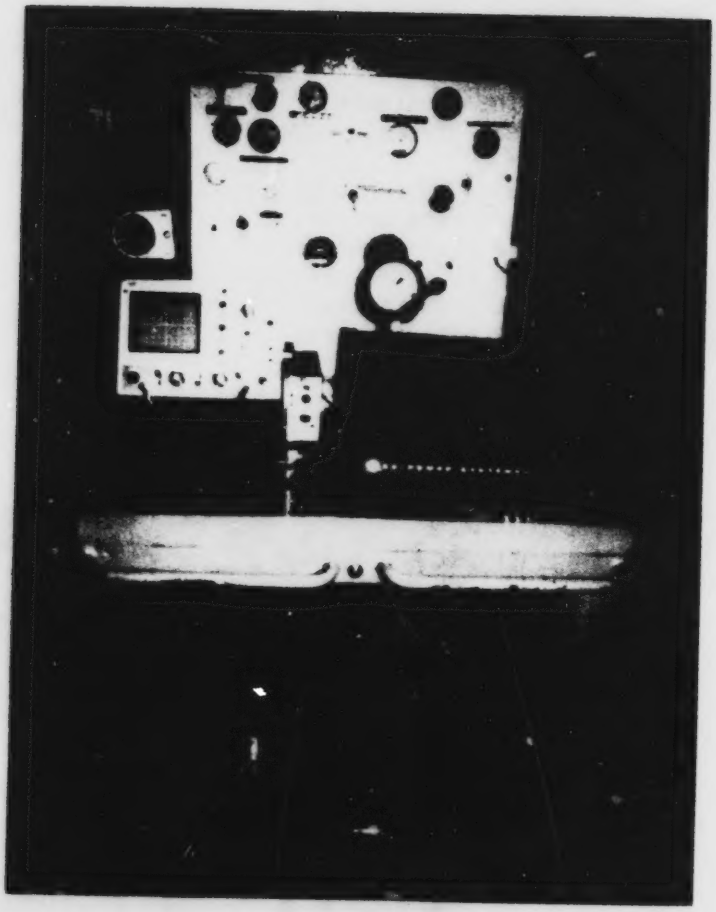


Photo 5 Control and Instrument Panel

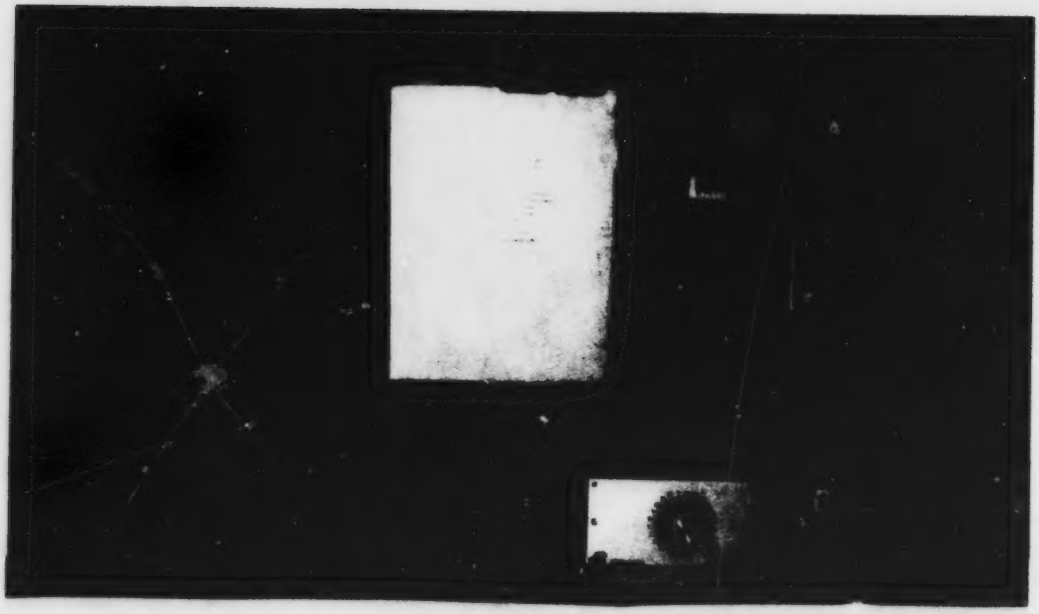


Photo 6 Thermocouple and Counter Panel

- Diesel Fuel Consumption. The net diesel fuel consumption was obtained by measuring the diesel supplied to the engine and subtracting the diesel returned to the tank. Two Halliburton turbine flowmeters were used during the first tests; in later tests, a Brooks oval gear flowmeter was used to measure supply diesel and a Halliburton turbine flowmeter to measure the return flow; later - two Brooks oval gear flowmeters were used to measure both flows.

The diesel fuel was drawn from a movable (caster mounted) tank on which the flowmeters, standpipe, valves, and auxilliary diesel fuel pumps were mounted. These items were arranged and piped so that the fuel supplied to the engine would come directly from the tank or from the standpipe; likewise the return could also be routed to either the tank or standpipe.

The transparent plastic standpipe (1-3/4 inch inside diameter acrylic tubing X 5 feet long) was marked near its bottom. Its volume between this mark and the overflow at the top was measured. The standpipe was used to calibrate and check the flowmeters; it was also used at times to measure flows during a test by timing the time taken to fill or drain it.

In all cases the temperature of the diesel fuel was measured (Mercury thermometer) at both the supply and return flowmeters. As the standpipe was connected to either flowmeter by a short length of hose (about 3 feet); the temperature of the diesel fuel in the standpipe was assumed to be the same as was measured at the connected flowmeter.

In early tests, the two flowmeters were both wired to one counter (this counter was capable of subtracting the counts from one flowmeter from the counts from the other flowmeter). After that, the flowmeters were wired so each had its own counter and sent electrical pulses to it only. The counters were controlled by the timer which was activated by closing a manual switch. The timer was capable of being set to a timed interval between .5 and 1000 seconds but was set to turn the counters off after an interval of about 3 minutes for these tests. Early tests were conducted with the assumption that the timers repeatability was good enough (with occasional checking with a stop watch). Later, each time interval was timed manually with a stop watch and, finally, the stop watch was wired to the timer circuit so that it was started and stopped by the timer.

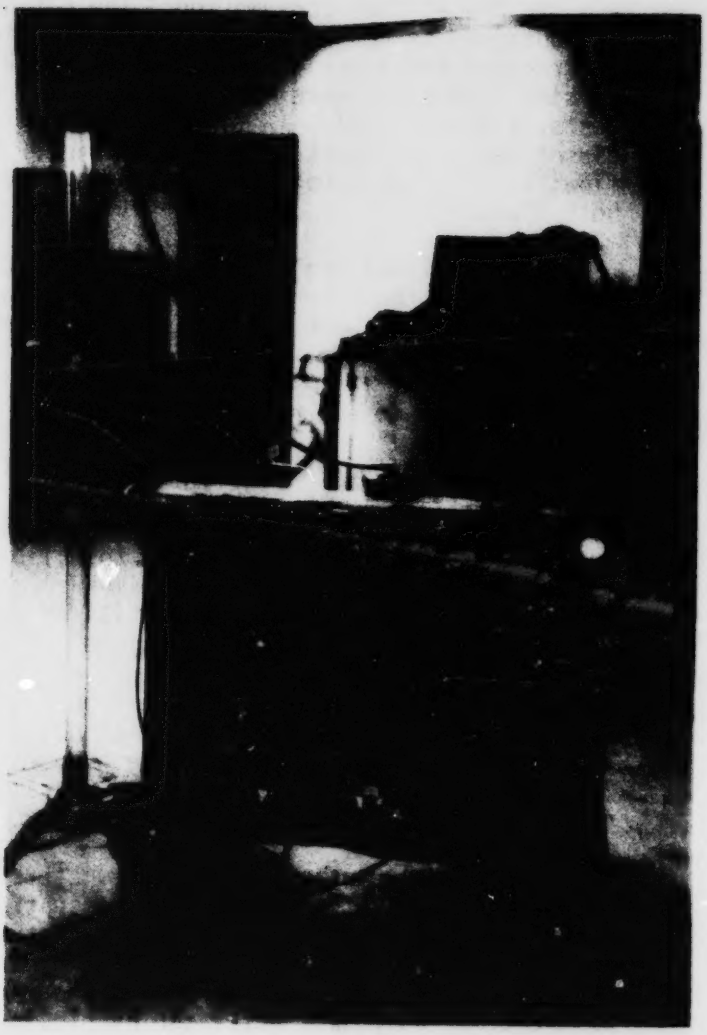


Photo 7 Overall Diesel Consumption
Measuring System

Photo 8 Close-Up of Diesel Fuel Flowmeters

- Propane Consumption. Propane consumption was measured with the test meter. It has a capacity of 260 cubic feet of propane per hour at a pressure drop of 1/2 inch of water.

The test meter was connected between the pressure regulator or vaporizer and the engine's air induction system. The pressure and temperature of the propane were measured at the meter's outlet. The pressure was measured with a water manometer (when it did not exceed ± 20 inches of water). At first the temperature was measured with a thermocouple which was later replaced by a Mercury thermometer.

This meter is equipped with a sweep hand which makes one revolution for each 0.1 cubic foot consumed (uncorrected). A photoelectric pick-up was mounted on the meter's front to facilitate the counting of this sweep hand. The timer circuit (discussed under diesel fuel consumption) and one counter were wired (through switches) to this pick-up.

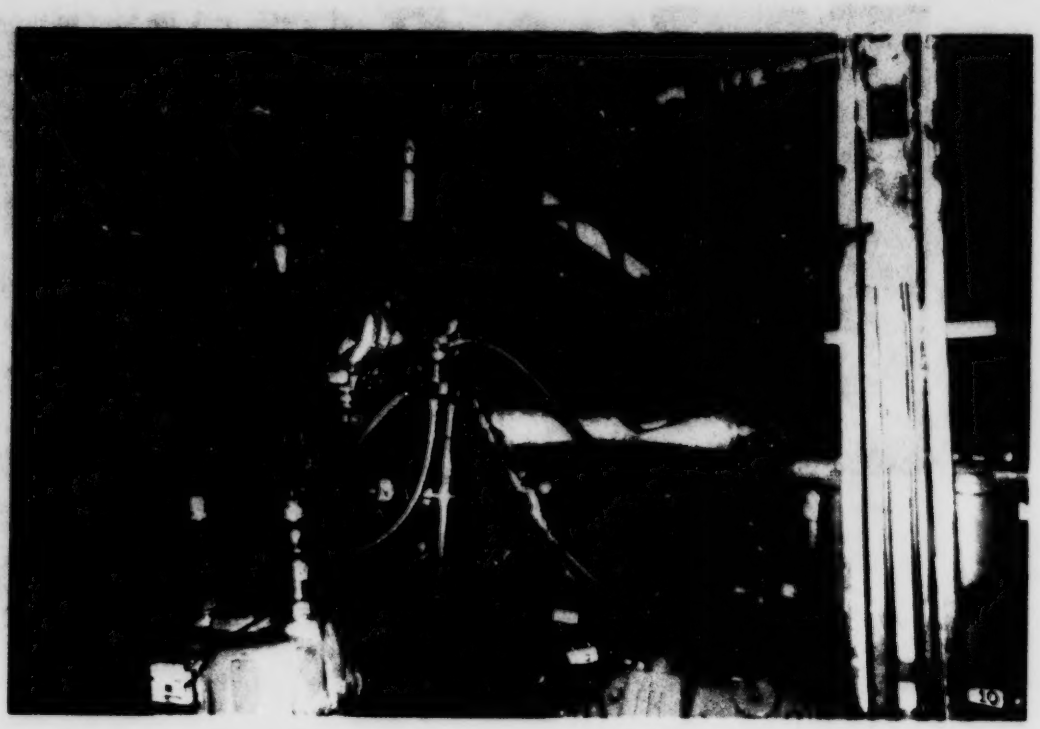


Photo 9 Propane Metering Equipment

- Engine Horsepower. Two measurements, engine revolutions per minute (RPM) and engine torque were made in order to calculate engine H.P.

Engine RPM was inititally set with the dynamometer tachometer but was measured more accurately for H.P. calculation purposes from a photoelectric pick-up - counter-stopwatch circuit which sensed the revolutions of the crankshaft pulley.

Engine torque was measured with the engine dynamometer, an agitator water brake type. This is a cradled type that senses the torque through a pair of hydraulic cylinders. The pressure (proportional to torque) induced in the cylinders is monitored on a pressure gauge on the console. The console has a factory pressure gauge whose face is calibrated to read directly in pound-feet. In later tests, a standard pressure gauge was used to monitor this pressure (this pressure, in pounds per square inch (psi), was multiplied by 4 to obtain the torque in pound-feet.

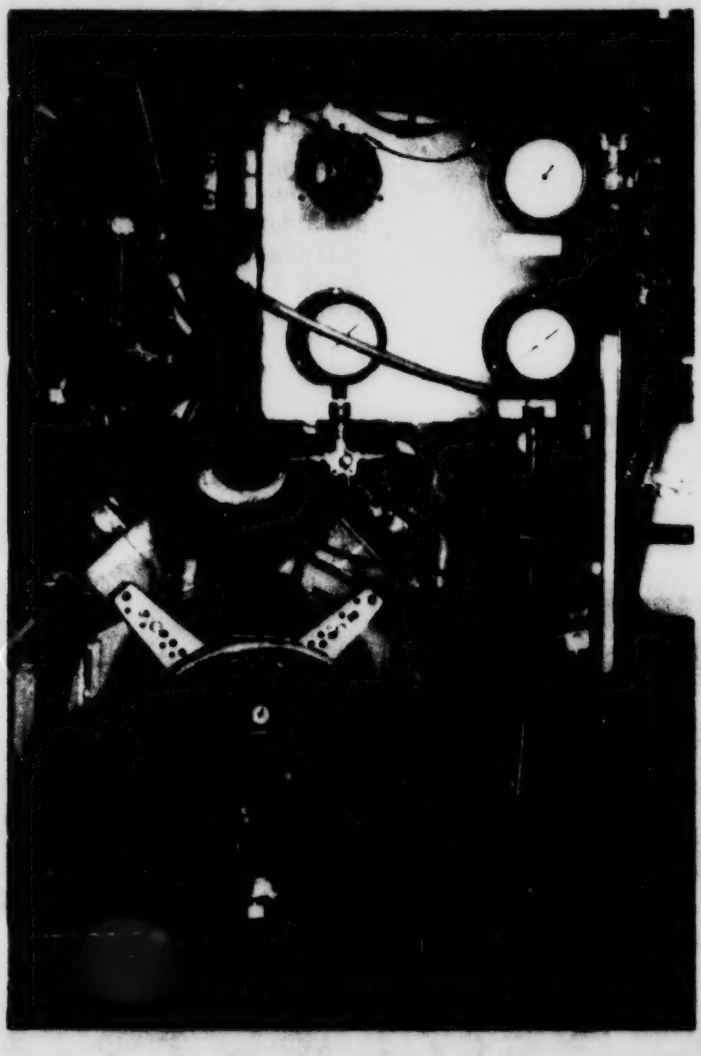


Photo 10 Engine Dynamometer

- Engine Cylinder Pressure. A hole was drilled and tapped into the left cylinder head and into the combustion chamber of cylinder #1. A piezoelectric transducer was screwed into this hole. The signal (from pressure variations) from the transducer was sent to a charge amplifier and then to an oscilloscope where it was displayed.

The signal from the photoelectric eye mounted on the front of the engine (RPM) was also fed to the dual trace oscilloscope; it was used to both trigger the oscilloscope and as a reference for the pressure wave in cylinder #1. The wave form was used to see if detonation or preignition was taking place and for comparisons between the propane/diesel tests and the diesel only tests.

- Engine Temperatures. Thermocouples were used to measure temperatures at:
  - Instrument panel
  - Engine water outlet
  - Turbine compressor inlet
  - Turbine compressor outlet (left & right)
  - cylinder air intake (Cyl.#1, & #2)
  - cylinder exhaust (Cyl. #1 & #2)
  - drive turbine inlet (left & right)
  - exhaust pipe
  - diesel fuel temperatures (primary filter & after pump)

Mercury thermometers (initially thermocouples) were used to measure temperatures at:

- air cleaner
- propane meter outlet
- diesel fuel (at each flowmeter)

Photo 11 Thermocouples - left side of engine

#1 - Engine water outlet
#2 - Drive turbine inlet (left)
#4 - Cylinder 1 exhaust
#7 - Compressor outlet (left)
#9 - Cylinder 1 air intake
#15 - Diesel fuel pump - return

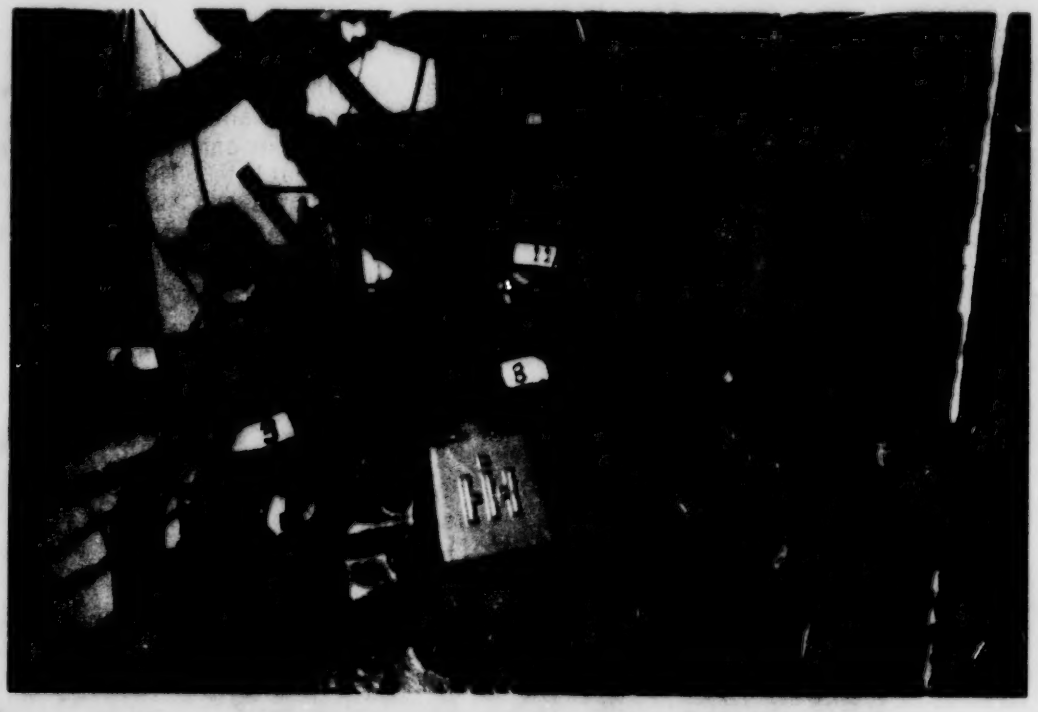


Photo .12 Thermocouples - right rear side of engine

#3 - Drive turbine -right
#5 - Cylinder 2 exhaust
#6 - Exhaust pipe
#8 - Compressor outlet - right
#10 - Cylinder 2 air intake
#11 - Compressor inlet
#14 - Diesel fuel - primary filter

Photo 13 Thermoucouples - right front side of engine

- Engine Exhaust Smoke. Engine exhaust smoke was measured with a Bosch smokemeter (sampling pump) and an evaluation instrument. The smokemeter drew a smoke sample from the exhaust pipe about 7 feet from the turbines outlet. This smoke sample was drawn through a paper filter disc in the smokemeter. The darkness of the paper disc was then read using the evaluation instrument.

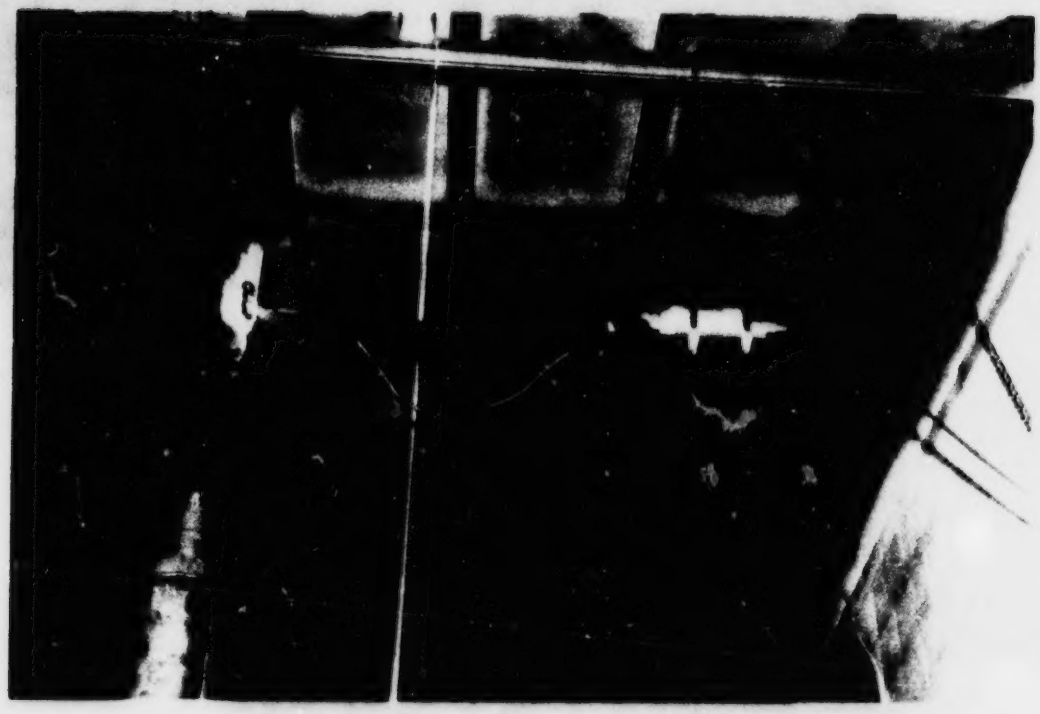


Photo 14 Smokemeter

- Ambient Conditions. Ambient conditions that were measured for these tests were: air temperature at air cleaner
barometric pressure
water vapor pressure

Air temperature was measured with a thermocouple during the first few tests but then a thermometer was used. Barometric pressures were obtained from Environment Canada, Atmospheric Environment Service, Climatology Department. These pressures are available every hour on the hour. Water vapor pressures were obtained by using a sling psychrometer to measure dry and wet bulb temperatures and plotting them on a psychrometric chart.

2.2.3 Calibration

- Diesel Flowmeters. A sample of diesel fuel was run through the flowmeters. The sample was caught, its temperature taken and then weighed. The counts registered by the flowmeters were recorded. An additional sample of diesel fuel was sent to an outside laboratory for a density determination (also a higher Heat Value). From these tests, a calibration factor for each flowmeter was calculated.

- Dynamometer. The dynamometer tachometer was calibrated using the photoelectric pick-up - counter - timer circuit which monitored the engine RPM. Calibration of the dynamometer torque unit was checked by attacking an arm to the dynamometer and applying a calibrated weight at a measured distance from the dynamometer center line (factory procedure).

2.2.4 Formulas used in Calculations

See Appendix B

2.2.5 Problems Encountered

Only those problem areas that had a large effect on accuracy will be discussed.

- Diesel flowmeters. Turbine type flowmeters were originally used to measure diesel fuel flow. They were found to be quite inaccurate for the flows and viscosities of the diesel fuel encountered in these tests (a 6.3% error in repeat accuracy was recorded). These meters were eventually replaced by positive displacement (oval gear) flowmeters.

- Timer. At first it was assumed that the timer could be set and that no further timing of its setting would be required. Some periodic checks revealed this not to be true (7.9% total maximum error was recorded in a 3 minute interval). Eventually a stop watch was interfaced to the timer (it was started and stopped by the timer) which reduced this error to about 0.01%.

2.2.6 Accuracy

Accuracy was primarily based on the precision of the measurements. An arbitrary maximum error of ± .2% was applied when an emperical formula was applied. Emperical formulas were used for:

A. diesel fuel density corrected for temperature
B. propane vapor density corrected for temperature and pressure (supercompressibility factors)
C. observed H.P. corrected to standard air inlet conditions.

Only maximum errors are discussed, probable errors would be half of this.

- Diesel Fuel Consumption. The following discussion applies to the latest set up (2 positive displacement oval gear flowmeters) for monitoring diesel duel consumption. Two errors were involved in this measurement; a calibration error and an actual test error. The calibration error (maximum) was caluclated to be ± .4%. The test error involved counting the flowmeter revolutions. This error decreased as the diesel fuel consumption increased. This measurement entailed counting the revolutions made by one flowmeter (supply diesel fuel) and subtracting the revolutions made by the other flowmeter (return diesel fuel). The maximum error for each flowmeter was the counts ± 1 count and the maximum error for the difference in counts would be counts ± 2 counts.

- Propane Consumption. The errors involved in this measurement were:

A. temperature and pressure measurement error of ± .75% maximum.
B. counting error involved with the counting of the meter sweep hand revolutions equal to counts ± 1 count.
C. propane density error due to the variation of the composition of propane (± 1.0% maximum) and an arbitrary error of 0.2% maximum in the application of the compressibility factor

- Horsepower Calculation. This calculation involved two measurements: RPM and torque. Both the RPM and torque varied fairly slowly as the engine governor tried to regulate the diesel fuel injected into the engine. The average RPM measured over the timed interval was very accurate (less than ± .1% maximum).

The procedure followed in setting or picking a value of the engine torque was to watch the pressure gauge needle vary for about 3 minutes. Then the position where the needle was positioned most of the time was estimated. It is felt that the maximum error in reading this torque was ± 6 pound feet. The maximum error in calibrating the dynamometer torque was felt to be ± 3 pound feet. The % error in the torque measurement decreased as the torque increased.

See Appendix C for the estimated errors experienced in certain tests.

2.3 Test Procedure

Before any tests were started, the engine was warmed up (about ½ hour) under no load to light load until the cooling water was up to normal operating temperature (about 175° F). The engine was then loaded to the desired test RPM (dynamometer tachometer) and torque (dynamometer) and held at this loading until all the engine temperatures had stabilized (about 15 minutes). At the same time, the engine's RPM and torque were monitored and adjusted, if necessary. The engine's RPM were not perfectly steady, the RPM varied about ± 25 RPM and the torque varied about ± 12 pound feet. These variations were not rapid but more a wandering type variation that was thought to be due to the hunting action of the diesel fuel injection pump. The RPM and torque were watched and what was felt to be the average value was recorded.

The date and time were recorded at the commencement of recording data for each test. The two diesel flow meters were always run simultaneously and the temperatures of the diesel fuel at these meters were read at this same time. Likewise, the propane meter and engine RPM (photoelectric pick-up) were run together along with the propane temperature and pressure at the propane meter outlet. As the timed procedures mentioned above each required 3 minutes, the engine's temperatures and pressures were monitored during these intervals.

Wet and dry bulb temperature readings (sling psychrometer) were obtained periodically during the day. Barometric pressures were obtained from Environment Canada at the end of each day covering the period that testing was conducted; the barometric pressure for each test was extrapolated according to the time of the test (from the hourly barometric pressures).

2.4 Test Results

2.4.1 Propane/Diesel Ratios

In this report, propane/diesel ratios are calculated on the basis of the weights (pounds per hour) of each of the fuels consumed.

Test results are shown in Appendix D. Some typical test results are summarized in Appendix E. Note that propane inducted into this engine: lowers the air intake manifold temperature, lowers the exhaust temperatures, raises the cylinder pressure (both peaks and the fluctuating component). Also, as the engine loading is reduced the propane/diesel ratio can be increased.

2.4.2 Engine Failures

Two engine failures were experienced during this test program. A full discussion of them is given in Appendix F.

Detonation (pressures were not monitored) could have been a factor in Failure #1, but high temperatures were definitely a factor as the piston was burnt.

In Failure #2, severe detonation did occur but none of the monitored temperatures were greater than 1000°F (this piston was not burned). Peak pressures reached 2320 psi and fluctuated 1450 psi in Cylinder #1 (Test #102). When the engine was run under the same load (Test #98) using diesel fuel only, the peak pressure was only 1380 psi. It is thought that the increased peak pressure was the cause of this failure. Its been suggested that the cylinder walls of a turbo charged diesel rely, to some extent, on the diesel fuel lubricating them. (The cylinders do not experience a negative pressure that could draw oil up past the rings from the crankcase).

2.4.3 Effects of Air Filter Condition

During an 11 hour endurance test, it was observed that the vacuum measured at the compressor inlet steadily got higher until it could no longer be read on the water manometer. The main engine air filter was found gradually to be becoming dirtier (primarily carbon from engine exhaust manifold leaks). A new air filter was purchased and some tests were rerun using the clean air filter and then the dirty filter (the dirty filter was a little dirtier than what is specified as acceptable in International's Maintenance and Service manual for this engine, - 2 inches of mercury).

It was found that a dirty air filter could dramatically increase the amount of propane inducted into the engine in some cases (see Appendix G). In a series of tests conducted on the Y'd carburetor set-up, 15 times as much propane was inducted into the engine when the dirty main air filter was used (as compared to a clean main air filter).

When a balance line (a line connecting the atmospheric side of the secondary diaphram of the vaporizer to the bottom of the air cleaner) could be used, it was found to stabilize the propane flow under different air filter conditions. The balance line could only be used when metering tubes were used. It was then found that a venturi had to be installed in the engine's air supply so that the engine would draw enough propane when a balance line was used. Two Venturis were tried; 5X4 and a 5X3.

It was found that the venturis did not significantly restrict the air flow to the turbine compressor's inlet. The 5X3 Venturi (with a metering tube installed) increased the vacuum at this point by about 4.5 inches of water (engine load of 400 pound-feet of torque and 2200 RPM - Test #370 compared to Test #364); when the propane hose was screwed directly into the 5X3 Venturi (no metering tube installed), the vacuum at the compressor inlet was increased by 2.5 inches of water (engine load of 400 pound-feet of torque and 2200 RPM - Test #371 compared to Test #364).

A Daisey Diesel Booster with its regulator set at a positive pressure of +15 inches of water is affected by the air filter's condition. In these tests, an increase of 50% more propane was inducted into the engine when the air filter was dirty. When its regulator was set to +5 psi, the system was affected very little by the air filter's condition.

3. CONCLUSIONS

The program entered upon in early 1981 and completed on December 31, 1983 was an important one. It was quite evident to the National Energy Board in 1980 that there were uncertainties about the availability of sources of crude oil required to satisfy the Canadian demand for motor fuels derived from the refining of crude. This was particularly true of imported requirements, which were necessary due to Canada not being self sufficient in crude supplies.

There was no doubt that TDC needed to study the possibilities of finding alternatives to this apparent uncertain oil supply. There were several avenues open that would require further investigation and research. Some of these being - Electrical powered vehicles, Propane powered vehicles, Natural Gas powered vehicles, and others. All of these alternatives would require further development and promotion. This was, and is, still going on through both Federal Government Grants and certain Provincial Government Tax incentives.

The alternative offered by Space Fuel Gas Products Ltd. was the induction of propane into diesel powered engines; a dual fuel system (propane/diesel). Space Fuel, having already patented a device for the induction of propane into the diesel engine and actively attempting to develop and market the system, became aware through certain adverse experiences that further research was absolutely necessary. They were, however, as a small independent marketing Company, unable to finance such a program by themselves.

The following are the conclusions arrived at by the project technicians:

3.1 Advantages of Using Dual Fuel (Propane/Diesel)

Some of the advantages of operating a diesel engine on dual fuel (propane/diesel) are:

a) Engine temperatures are reduced. Temperatures in the air intake manifold are reduced a little. It was reduced about 10° F when a propane/diesel ratio of .20 was used. It was reduced about 20°F when a propane/diesel ratio of .40 and larger was used. Engine exhaust gas temperatures were also reduced. They were about 30° F less when a propane/diesel ratio of .20 was used. The reduction in exhaust temperatures was even more for larger propane/diesel ratios up to at least .70. When the propane/diesel ratio was increased to 1.1, the temperatures were more varied and most of them increased - which leads one to wonder if the propane was equally distributed to all the cylinders.

b) Cleaner engine. The engine components are cleaner. This was noted when the repairs to the engine were done.

c) Exhaust smoke is reduced. Exhaust smoke is reduced although it is not a drastic reduction.

3.2 Disadvantages of Using Dual Fuel (Propane/Diesel)

Some disadvantages of operating a diesel engine on dual fuel (propane/diesel) are:

a) Cylinder pressures increase. Both the peak pressure and the fluctuating component increase with an increasing propane/diesel ratio but this increase is also related to the engine load. At light engine loads (low torque), a propane/diesel ratio can be used that would fail the engine at a heavier loading.

b) No savings in Total Fuel Cost. It is felt that the total fuel cost would be the same for either dual fuel or diesel only operation. In some calculations, a saving was found but in others (tests) a loss would be found. In these calculations, a cost of 28.5 cents/liter was assumed for diesel fuel and 18.5 cents/liter for propane. If the spread between the cost of diesel fuel and propane widened, than a savings in total fuel cost would be realized.

c) Additional first cost. A dual fuel conversion would involve an additional cost for the propane tank, equipment and installation.

d) More weight. A dual fuel conversion involves the additional weight of the propane tank and equipment. In some applications this is a penalty as it would reduce the pay load. The total weight of fuel used would be about the same for either dual fuel or diesel only operation.

e) Inconvenience. Gradually, more service stations are adding facilities to handle propane but usually the propane facilities are located at some distance from the diesel pumps. This poses an inconvenience and a time penalty involved in moving a truck to fill the propane tank.

f) Precautions necessary around a Propane Filling Facility. There have been cases where a diesel engine has run away (engine revved up) and self destructed when propane got loose in the air around the engine. A spark ignition engine would only flood itself and stop under similar conditions. This means that the filling service personnel and the truck operator would have to be more cautious when a diesel engine was close by and running.

Our final conclusions are that the program was effective as far as it went. There is evidence that propane can be successfully induced into the diesel engine within certain parameters that will reduce the consumption of diesel fuel (replaced with propane) without having to affect horsepower.

We were able as the reports show, to determine limitations of propane replacement. We were able with some tests to show disadvantages of inducing propane into the diesel engine, where increase in horsepower was achieved. It is interesting to note that the system that was used in the final tests was so modified during the period of testing that it barely resembled the initial system initiated in the program. It was because of the many unknowns about this system that many problems were encountered throughout the duration of the laboratory tests and resulted in certain failures which, in turn, delayed the completion of all detailed schedules of work.

We had scheduled a program to convert certain diesel operated over the road transports to use dual fuel. Arrangements to obtain certain vehicles had been worked out with the operators. We had planned approximately a 90-day program to accomplish these tests with sophisticated monitoring systems and personnel to travel with drivers on these tests. This portion of the program had to be dispensed with due to delay, breakdowns, and the approach of the contract termination.

We, of course, believe that this type of field test should be done at some later date as this would assist greatly in perfecting the metering system to provide the proper ratio of both fuels under all driving conditions.

It was however felt by TDC that crude oil supply and pricing uncertainties were evident at the time the Contract was entered into; but which now are not nearly as serious. There is much more stability in imported oil supply and pricing and Canada is moving closer to self sufficiency in oil production. With these facts being considered TDC did not feel that the Contract need be extended, nor could further extension of funding be substantiated in the light of these facts. It is possible and should be considered, that if the supply situation deterioratesin the future, this phase of the program should be further considered, as we are convinced that dual fuel propane/diesel is feasible and will conserve diesel fuel.

3.3 Field Applications

Propane can be used and is used as a horsepower boost. We do not recommend this as too many engine failures have been the result.

The purpose of this research was not to increase the horsepower output of an engine,but rather to replace a portion of the diesel fuel with propane without adversely affecting the engine's performance and life. Any of the propane induction equipment tested in this research would automatically give a horsepower boost. A device would be required that will limit the engine from increasing its horsepower output beyond its rating. Any application in which an overrunning load (truck going down a steep hill) can be applied to the engine will require a device to shut off the propane when the throttle is not depressed. The Daisey Diesel Booster does this by using a metering valve that is linked back to the throttle (this metering valve also proportions the propane flow at intermediate positions of the throttle).

3.4 Comparisons - Propane Induction Systems

The major difficulty encountered with most of the propane induction systems tested was that of counteracting the effects caused by the air filters changing condition;as an air filter becomes dirtier it causes a larger pressure drop (vacuum) to occur across the vaporizer or regulator and, consequently, draws more propane from it.

- Metering tubes - The flow from a metering tube - vaporizer (½" of water) setup is very sensitive to the pressure drop across it. This setup requires a balance line and in most applications it is thought that a venturi would be required to make them draw enough propane.

- Venturi Tubes - Venturi tubes are required to produce enough pressure drop across the vaporizer (with balance line) so that propane could be drawn into the engine. Metering tubes can be installed in the Venturi tubes but it is a cleaner system if the propane is piped directly into the Venturi. The Venturi tube - vaporizer (with a balance line) system is similar to metering tubes in its behaviour. It can be designed to cut the propane off at lower RPM's (lower air flows). A properly designed Venturi will not restrict the air flow too much (possibly 4 inches of water).

- Y'd Carburetor - The problems associated with air filter condition are doubled with this system as two filters are now involved. (The engine's main filter and the Y'd carburetor's filter). This system could be made to operate but it is thought it would be too complicated.

- Daisey Diesel Booster- The Daisey Diesel Booster with its regulator set at +15 inches of water is affected by the air filter's condition (up to 50% more propane with a dirty filter). When the regulator is set to +5 psi, the effects produced by filter conditions are minimal. This system draws propane from the top of the propane tank and the amount of propane supplied to the engine can be greatly curtailed by the effects of cold weather and/or the quantity of propane in the tank.

3.5 Possible Reduction of Diesel Fuel Consumption

The comments made here are based on the tests that were conducted on the test engine (International 573-B). It is felt that the life of the engine would not be adversely affected if a propane/diesel ratio (weight basis) of .25 was used. This would be about a 20% reduction in diesel fuel consumption. Peak cylinder pressures would be about 7% higher and the fluctuations in pressure would be about twice as much (100 psi more). Engine temperatures, both intake manifold and exhaust would be a little lower. Field tests, conducted over a period of time are required to determine if fatigue of some of the engine parts would be a problem.

Comments cannot be made about engines of a different design which differ in compression ratio, combustion chamber design, boost pressure, timing and RPM. It is thought that a two cycle diesel engine would be too wasteful of propane to be even considered for dual fuel operation.

4. RECOMMENDATIONS

The program should be continued at some later date using the information developed under this Contract, providing certain developments in the future warranted the use of a propane diesel system for diesel operated engines. These conditions could be as follows:

a) Should there at some time in the future be an indication that there will be a shortage of crude oil, either in Canadian production, or in international situations developing whereby imports are restricted.

b) Should it prove more economical to substitute a certain portion of the diesel fuel with propane. It is recommended that if and when further research is done sometime in the future, that the system tested under this program be utilized with certain modifications dictated by the application that is used.

Future tests should be done on over the road diesel operated vehicles. In the selection of such vehicles, consideration should be given to the efficiency of the Company operating them. An operating transport company that maintains good operating records, has well trained drivers, and has a good vehicle maintenance program is essential to such a testing program.

The operating records of the vehicle to be tested with the dual fuel system should be studied prior to the field test being made; this will save time which otherwise would require time before the field test begins, in developing pre-testing data. One of the objections that will be encountered in using a test vehicle owned by others is the possibility of any damages to the engine that might occur as a direct result of the induction of propane into the diesel engine. This is not very likely to happen but errors can be made. In the event that such damage did occur, as a result of these tests, then the Contractor has to be prepared to indemnify the owner of the vehicle for the full cost of repairing these damages.

It is further recommended that a fully automatic system has yet to be developed for the accurate metering and control of the ratio of propane to diesel for all operating conditions. In other words, the percent of diesel fuel consumed in a diesel engine operating @ 1000 RPM and 20% torque would use less propane to diesel fuel than the engine operating at 2400 RPM and 90% torque.

Thus, it is essential that the device to control this portion of the operation needs to be further developed and researched.

We are convinced that induction dual fuel system is a workable system and should be further tested and researched.

APPENDIX A Instrumentation used in Laboratory Tests

Dynamometer: Go Power DT-1000

Dynamometer Console: Go Power 10

Oscilloscope - Dual Trace: BK 1476

Piezoelectric Pressure Transducer: Kistler 609-C

Charge Amplifier - Pressure transducer: Kistler 500A

Thermocouples: Instrumatics CR-AL

Thermocouple Readout: Thermo-Electric 31620

Thermocouple Rotary Switch: Thermo-Electric, 23 position

Timer: ISSC Model 1018

Counters: Red Lion Model 401
Model 662

Liquid Flowmeters: Brooks LS-45, 10-200 LPH
Halliburton, 3/8, 70-680 LPH

Gas Flowmeter: Rockwell RC-415

Smoke Meter: Bosch EFAW 65A

Smoke Meter Readout: Bosch EFAW 68A

Photo-electric Pick-Up: Powers 836-5X8

APPENDIX B Formulas used in Calculations

- API Standard 2540 (1980) - Volume Correction Factors.
  These formulas were used to determine the density of the diesel fuel. This was based on the diesel fuel temperature at the flowmeter and the base density ($60^{o}F$) as measured by an outside laboratory.

- SAE J 1349 (Dec.80) - Engine Power Test Code.
  This standard was used for correcting the observed horsepower to standard air conditions.

- Engineering Data Book (by Natural Gasoline Supply Mens' Association - 1957 - - Pages 100 & 101).
  These formulas and graphs were used in applying a compressibility factor to the propane flow.

- Performance Curve supplied with Gas Meter.
  This was used in applying a correction to the meter's measured flow.

APPENDIX C Examples of Typical Accuracy Attained

Test	Diesel Consumption	Propane Consumption	Torque	Propane/Diesel Ratio
88	± 10.7%	± 4.7%	± 7.5%	±15.9%
100	± 1.8%	± 2.9%	± 3.0%	± 4.8%
273	± 3.0%	± 3.0%	± 9.0%	± 6.1%
297	± 1.3%	± 2.9%	± 2.0%	± 4.2%
322	± 1.1%	± 3.8%	± 1.7%	± 4.8%

APPENDIX D Test Results

Tests	1	-	120	Daisey Diesel Booster
	181	-	192	Metering Tubes
	201	-	254	Metering Tubes
	260	-	287	Y'd Carburetor Set-up
	290	-	311	Endurance Test
	312	-	345	Air Filter Tests
	346	-	388	Balance Line and Venturi Tests

APPENDIX E Some Typical Test Results

Test	RPM	Torque (lb-Ft)	Propane Diesel (Wt.Basis)	% Reduction in Diesel	Cyl #1 Pressure (psig) Peak	Cyl #1 Pressure (psig) Variation	Temperatures - (^{o}F) Intake Manifold	Cylinder #1	Cylinder #2	Drive Turbine Inlet Lt.	Drive Turbine Inlet Rt.	Exhaust Pipe
315	2207	544	0		1740	70	292	1170	1162	1222	1212	996
322	2199	544	.14	12.3	1800	90	288	1159	1157	1207	1220	993
234	1579	500	0		1520		209	1186	1175	1265	1257	1125
237	1591	500	.22	17.5	1600		200	1148	1115	1236	1228	1096
291	2208	456	0		1420	60	258	1157	1144	1182	1179	994
297	2211	460	.42	30.8	1860	350	237	1110	1077	1120	1131	957
98	2393	300	0		1380		213	908	903	933	932	780
100	2377	300	.69	42.9	1740	220	194	901	827	927	858	760
102	2397	300			2320	1450			Engine Failed			
271	2393	100	0		700	100	158	671	674	658	661	584
273	2377	100	1.10	43.9	750	120	149	800	709	730	584	575

APPENDIX F Engine Failures

First Engine Failure

This failure occurred on April 14, 1983. The engine seized up and was very hot. The engine was being readied for a test before this failure occurred and only the engine torque and RPM were monitored. The engine was under a load of 500 pound feet of torque at 2400 RPM. Propane was being induced into the engine.

Both heads were removed. Piston #4 was badly burned and its sleeve was badly scarred; they were both replaced. The sleeve in Cylinder #2 was slightly scored; it was honed. The valves had chatter marks on their seating surfaces (from the engine overhaul prior to laboratory testing). The valves could not be re-ground and had to be replaced. The valve seats were re-ground except for one valve seat in Cylinder #4 which had to be replaced.

Cooling water had been leaking into Cylinder #1 from the piezo-electric pressure probe installed in it. There was some rust on the sleeve; it was removed with emery cloth. The injector for Cylinder #4 was removed and tested; it was still within specifications. All other engine parts appeared to be in good shape.

Photo 15 Pistons - Engine Failures

Previous laboratory engine history prior to First Failure

1. This engine had been purchased as a completely reconditioned engine for these laboratory tests. After the laboratory tests had been started, the injector pump and injectors had been removed, tested and adjusted on February 25, 1983. Diesel fuel had been observed dripping out of the right exhaust manifold during engine warm-ups on April 12 & 13; this manifold was removed and it was observed that the ports to Cylinders #2, 6 & 8 were set while the port to Cylinder #4 was dry (eventual cylinder to fail).

2. Under laboratory testing the engine had seen the following loading:

   a) 600 pound feet of torque at 2400 RPM with propane inducted. No temperatures were recorded.

   b) 530 pound feet of torque at 1600 RPM. The recorded temperatures were 1460°F at the drive turbine inlet and 1260°F at the exhaust pipe. These were the highest temperatures that were ever recorded during the project.

Second Engine Failure

On September 15, 1983 the engine failed during a test in which a large amount of propane was inducted into the engine. The engine was being readied for a test (Test #102). Temperatures were observed (none over 1000°F) but were not recorded. The engine was working under a load of 300 pound feet of torque and 2400 RPM. Propane flow was measured and calculated to be 29.6 liters/hour (32.9 pounds/hour). The diesel fuel consumption was not measured but it was assumed to be the same as that monitored in Test 101 (likely it was less), then the propane/diesel ratio (weightwise) would be 1.01.

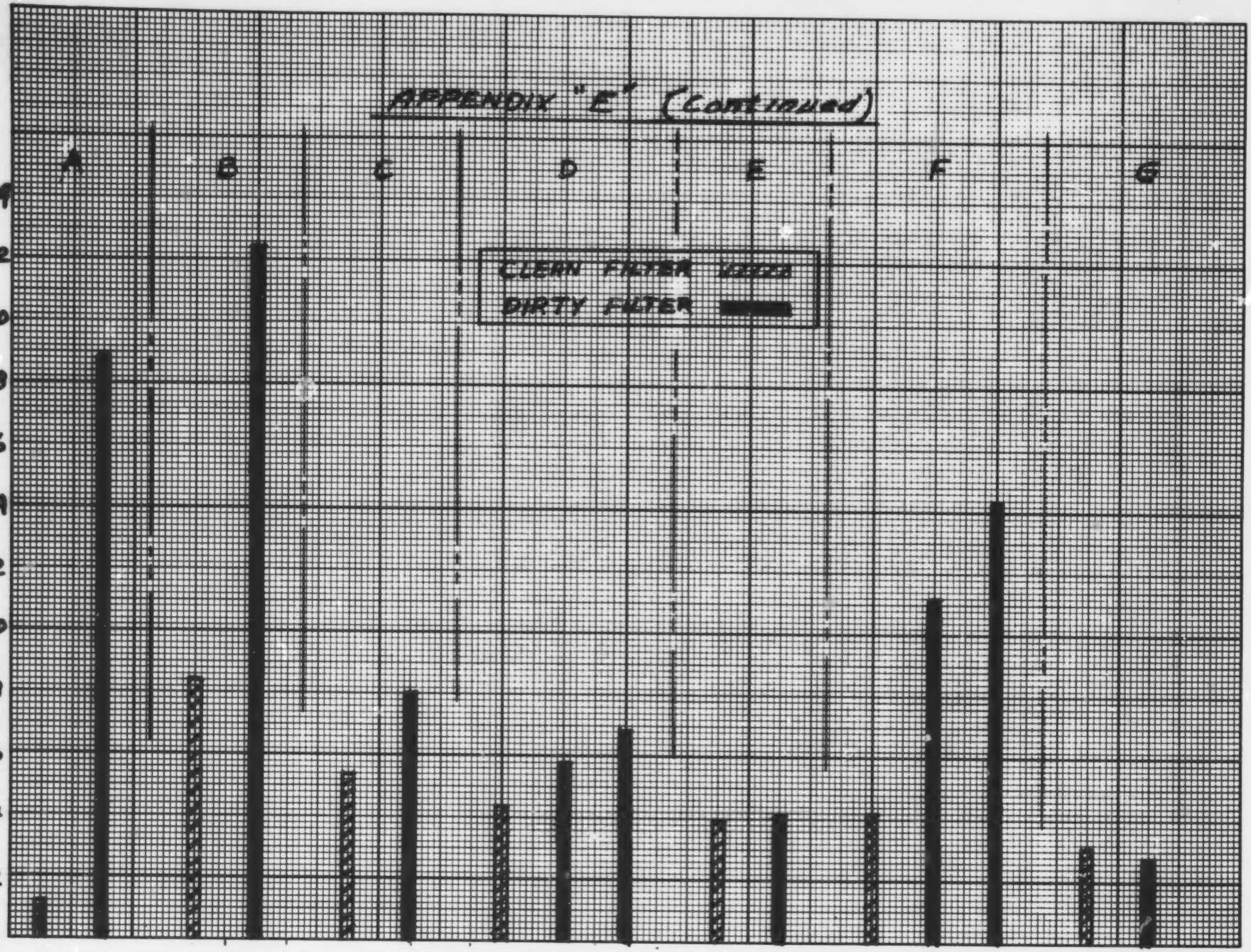
Severe detonation was taking place. Peak pressures of 160 bars (2320 psi) and pressure fluctuations of 100 bars (1450 psi) were observed. The engine ran under these conditions for about 5 or 6 minutes before it failed.

The left head was removed. The poston and sleeve in Cylinder #3 were badly scarred. The trade calls this a collapsed piston due to heavy loads and/or poor lubrication. This piston and sleeve were replaced and the valves for Cylinder #3 were re-ground. The cylinder walls of #1, 5 and 7 appeared to be in good shape. The right head was not removed.

APPENDIX G Effects of Air Filter Condition

	Propane System	Test No.	Main Filter Condition	Pressure @ Compressor Inlet (Inches Water)
A	Y'd Carburetor	316	Clean	- 5.0
	Impco 425	308	Dirty	-19.5
B	Y'd Carburetor	329	Clean	- 3.2
	Holley 902	327	Dirty	< -20.0
C	Daisey Diesel	330	Clean	- 3.4
	.128 Nozzle	331	Dirty	< -20.0
	Reg. @ 15" Water			
D	Daisey Diesel	334 & 335	Clean	- 3.6
	.110 Nozzle	333	Dirty	-19.9
	Reg. @ 15" Water	332	Dirty	< -20.0
E	Daisey Diesel	336	Clean	- 3.6
	.080 Nozzle	337 & 338	Dirty	-20.0
	Reg. @ 5 PSI			
F	Metering Tube	342	Clean	- 3.4
	3-36	340	Dirty	-22.0
	w/o Balance Line	339	Dirty	< -22.0
G	Metering Tube	344	Clean	- 3.8
	3-36	341	Dirty	< -20.0
	Balance Line			

APPENDIX "E" (CONTINUED)



1 TO 120 DAISY

DAISEY DIESEL - REGULATOR SET @ 15" H_2O, .128 ORIFICE

DIESEL 28½ ¢/L 19505 BTU/# 847 KG/m^3 ; PROPANE 18½ ¢/L 21800 BTU/#

#/HR

ENGINE LOAD				DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE		DIESEL - PROPANE / DIESEL				
RPM	TORQUE #-FT	BHP (UNCOR.)	BHP. CORR.	SUPPLY L/HR	RETURN L/HR (FLOWMETERS STANDARDIZE)	NET L/HR	#/HR	#/BHP-HR (UNCORRECT CORRECTED)	BTU/HR (1000)	COST/HR	L/HR ft³/HR	#/HR (DIESEL & PROPANE)	BTU/HR (1000)	COST/HR	TOTAL COST PER HR	BTU HR. (1000) TOTAL #/HR.	O/O DIESEL	RATIO OF BTU'S	SAVING IN FUEL COST	Fuel Cost /BHP HR (UNCORR. CORR.)	TEST NO.
1367	100	26.4	28.9	129.61	120.55	9.06	16.92	.641	330	2.58										.098	1
					120.31			.585												.089	
1375	100	26.2	28.8	123.01	115.46	7.55	17.84	.773	347	2.72	2.16	2.41	52	.90	3.12	400	105.4	1.213	-.54	.119	2
					118.39			.703			20.7					20.25				.108	
1570	100	29.9	32.9	139.53	124.08	15.45	28.84	.964	562	4.40										.127	3
					124.64			.878												.134	
1574	100	30.0	33.0	133.76	124.17	9.59	17.90	.691	349	2.73	2.51	2.80	61	.49	3.22	410	62.1	.729	1.18	.107	4
					125.61			.627								20.71				.098	
1778	100	33.9	37.3	136.72	124.48	12.24	22.85	.675	445	3.49										.103	5
					127.29			.612												.093	
1778	100	33.9	37.3	131.75	126.91	10.84	20.25	.697	394	3.09	3.02	3.37	73	.59	3.68	468	88.6	1.051	-.19	.109	6
					129.13			.633								23.61				.099	
1782	100	41.6	45.7	138.47	121.79	16.68	31.14	.749	607	4.75										.114	7
					124.18			.682												.104	
2187	100	41.7	45.9	139.54	126.25	13.29	24.82	.711	484	3.79	4.31	4.80	104	.84	4.63	588	79.7	.969	.12	.111	8
					128.29			.695								29.62				.101	
2367	100	45.1	49.8	139.39	123.55	15.84	29.58	.656	576	4.51										.120	9
					124.67			.594												.091	
2352	100	44.9	49.6	141.52	127.54	13.98	26.11	.691	509	3.99	4.45	4.96	108	.87	4.85	617	88.3	1.070	-.34	.108	10
								.626								31.07				.098	

DIESEL 28½ ℓ/L 19505 BTU/# 847 KG/m³ ; PROPANE 18½ ℓ/L 21800 BTU/#

ENGINE LOAD				DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE		DIESEL-PROPANE		DIESEL		
RPM	TORQUE #-FT	BHP (UNCORR.)	BHP. CORR.	SUPPLY L/HR	RETURN L/HR FLOW METER STANDPIPE	NET L/HR	#/HR	#/BHP-HR UNCORRECT CORRECTED	BTU/HR (1000)	COST/HR	L/HR ft³/HR	#/HR # DIESEL & # PROPANE	BTU/HR (1000)	COST/HR	TOTAL COST PER HR	BTU/HR. (1000) TOTAL #/HR.	% DIESEL	RATIO OF BTU'S	SAVING IN FUEL COST/HR	#/BHP-HR UNCORRECT CORRECTED	TEST NO
	DIESEL		DIESEL	BOOSTER	-	REGULATOR	SET @	15"	H_2O	- .128	ORIFICE										
1875	312	111.4	124.3	139.27	115.16	24.11	45.01	.434	87.2	6.87										.062	11
					113.98			.362												.055	
1875	312	111.4	124.3	142.31	115.27	27.03	50.48	.453	984	7.70										0.069	12
					113.98			.406												.062	
1829	312	108.7	122.6	139.52	116.65	22.85	42.67	.432	832	6.51	3.87	4.31	93	.72	7.23	926	94.8	1.055	-.36	.067	13
					119.01			.383								46.98				.059	
1829	312	108.7	122.6	139.52	116.65	22.85	42.67	.432	832	6.51	3.87	4.31	93	.72	7.23	926	84.5	.941	.48	.067	14
					119.01			.383								46.98				.059	
2185	300	124.8	139.4	145.25	115.48	29.77	55.59	.445	1084	8.48										.068	15
					111.89			.399												.061	
2176	300	124.3	138.9	143.70	117.99	25.71	48.01	.424	936	7.33	4.19	4.66	101	.77	8.10	1038	86.4	.957	.38	.065	16
					119.34			.379			40.1					52.67				.058	
2359	300	134.8	150.3	141.51	109.75	31.76	59.30	.440	1156	9.05										.067	17
REGULATOR	SET @	30"	H_2O		109.71			.395												.060	
2359	300	134.8	149.9	142.48	114.04	28.44	53.10	.440	1035	8.10	5.60	6.24	135	1.04	9.14	1171	89.5	1.013	-.09	.068	18
					119.67			.396			53.7					59.34				.061	
	REGULATOR	SET	BACK	TO	15"	H_2O															
2369	300	135.3	146.6	148.75	119.59	29.16	54.45	.442	1062	8.31	4.78	5.32	116	.88	9.19	1178	91.6	1.016	-.12	.068	19
					118.10			.408			45.8					59.77				.063	
2366	300	135.2	145.7	145.59	113.74	31.85	59.47	.440	1160	9.08										.067	20
					112.21			.408												.062	

DIESEL 28½ ¢/L 19505 BTU/# 847 KG/m³ ; PROPANE 18½ ¢/L 21800 BTU/#

ENGINE LOAD				DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL + PROPANE		DIESEL - PROPANE / DIESEL				
RPM	TORQUE #-FT	BHP (UNCOR.)	BHP. CORR.	SUPPLY L/HR	RETURN L/HR FLOW METER STANDPIPE	NET L/HR	#/HR	#/BHP-HR UNCORRECT CORRECTED	BTU/HR (1000)	COST/HR	L/HR ft³/HR	#/HR # DIESEL # PROPANE	BTU/HR (1000)	COST/HR	TOTAL COST PER HR	BTU HR. (1000) TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVING IN FUEL COST	#/BHP-HR UNCORRECTED CORRECTED	TEST NO
	DAISEY		DIESEL	BOOSTER	- REGULATOR	SET @	15" H_2O	- .128	ORIFICE												
2359	500	224.6	237.0	145.42	95.76	49.66	92.73	.413	1808	14.15										.063	21
					94.19			.391												.060	
2374	500	226.1	239.0	144.91	98.58	46.33	86.50	.407	1687	13.20	4.85	5.41	117	.90	14.10	1805	93.3	.998	.05	062	22
					98.13			.385			46.5	16.0				91.91				059	
2182	500	207.7	225.2	141.98	96.44	45.54	85.04	.409	1658	12.98										.062	23
					96.88			.378												.058	
2192	500	208.7	227.4	140.54	99.41	41.12	76.79	.393	1497	11.72	4.63	5.16	112	.86	12.58	1610	90.3	.971	.40	.060	24
					98.57			.360			444	14.9				81.96				.055	
2182	500	207.7	224.8	140.83	95.75	45.08	84.18	.405	1641	12.85										6.18	25
					95.85			.375												5.72	
2192	500	208.7	227.4	140.54	99.41	41.12	76.79	.393	1497	11.72	4.63	5.16	112	.86	12.58	1610	91.2	.981	.27	6.03	26
					98.57			.360			444	14.85				81.96				5.53	

FUEL DATA → DIESEL 28.5 ¢/LITER, 19505 BTU/#, BA1 FOR 27 B59 FOR REST KG/M³; PROPANE, 18.5 ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE ft-FT	BHP UNCORRECT (CORRECTED)	SUPPLY L/HR	RETURN Flowmeters STANDPIPE L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST $/HR	L/HR (ft³/HR)	#/HR % DIESEL % PROPANE	BTU/HR (1000X)	COST $/HR	TOTAL FUEL COST $/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST $/HR	¢/BHP-H UNCORRECT CORRECTE
	WATER		INJECTION		ONLY																
27	2191	500	208.6	140.41	95.80	44.61	83.30	.399	1624	12.71							COMPARE TO 25				
			230.9		95.82			.361										99.0	.990	.14	6.10
																					5.51
	WATER		INJECTION	& DAISEY		DIESEL		BOOSTER - REG @ 15" H_2O - .128 ORIFICE													
28	2177	500	207.3	147.93	105.38	41.96	78.34	.403	1528	11.96	4.65	5.18	112	.86	12.82	1640	83.52	93.1	1.000	.03	6.18
			225.4		104.75			.371			44.5	15.13									5.69
29	2169	500	206.6	144.49	103.92	40.57	75.76	.392	1477	11.56	4.61	5.14	112	.85	12.42	1589	80.89	90.0	.969	.43	6.01
			225.2		103.54			.359			44.2	14.75									5.51
30	2169	500	206.6	140.92	99.42	41.00	76.55	.395	1493	11.68	4.61	5.14	112	.85	12.54	1605	81.69	90.9	.978	.31	6.07
			225.6		99.53			.362			44.2	14.90									5.56

FUEL DATA → DIESEL 28.5 ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE, 18.5 ¢/LITER, 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECTED)	SUPPLY L/HR	RETURN Flowmeters STANDPIPE L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR DIESEL/PROPANE RATIO	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT CORRECT
		DIESEL		DIESEL	BOOSTER - REGULATOR @ 15" H_2O - .128										ORIFICE						
31	1229	104	24.3	112.71	104.75	7.96	14.87	.611	290	2.27											9.32
			26.4		105.15			.562													8.58
32	1216	100	23.2	111.49	104.25	7.24	13.53	.770	263	2.06	3.86	4.30	93	.71	3.78	357	17.23	91.0	1.233	-.51	12.02
			25.1		104.59			.712			27.0	3.14									11.09
33	1218	—	—	—	—	—	—	.769	—	—	3.87	4.31	94	.72	—	—	17.84	—	1.234	—	11.99
			—					.710			37.1	3.13									11.07
34	1216	—	—	—	—	—	—	.674	—	—	1.87	2.08	45	.35	2.41	309	15.61	91.0	1.066	-.14	10.40
								.622			17.9	6.50									9.61
35	1014	100	19.3	93.35	86.39	6.96	13.00	.673	253	1.98											10.27
			20.8		86.57			.624													9.52
36	1020	—	19.4	104.00	87.82	16.18	30.22	1.672	589	4.61	2.04	2.27	49	.38	4.99	638	32.49	232.5	2.520	-.301	25.67
			21.0	↑	87.87	↑		1.550	.		19.5	15.32									23.80
37					One of Diesel Counters must have been read wrongly																
38																					

38-5

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE, 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECTED)	SUPPLY L/HR	RETURN FLOWMETERS STOPPED L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR #DIESEL #PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECTED CORRECTED
		DIESEL		DIESEL	BOOSTER	–	REGULATOR @				15"	H_2O	–	128	ORIFICE						
39	812	100	15.5	74.58	69.06	5.51	10.30	.666	200	1.57											
			16.7		69.02			.616													10.16
																					9.40
40	821	100	15.6	75.16	70.40	4.76	8.89	.675	173	1.36	1.49	1.66	36	.28	1.63	209	10.56	86.4	1.044	-.06	10.44
			16.9		70.36			.625			14.3	5.35									9.67
41	814	–	15.5	–	–	–	–	.773	–	–	2.78	3.09	67	.51	1.87	240	11.99	–	1.200	-.30	12.06
			16.8		–			.714			26.6	2.88									11.15
42	804	–	15.3	–	–	–	–	.836	–	–	3.52	3.92	85	.65	2.01	258	12.81	–	1.289	-.44	13.10
			16.6		–			.773			33.7	2.27									12.11
43	824	100	11.9	55.71	51.04	4.66	8.71	.733	169	1.33											
			12.9		50.76			.677													11.18
																					10.34
44	668	100	12.7	61.46	58.26	3.39	6.34	.786	123	.97	3.29	3.67	79	.61	1.58	203	10.00	72.7	1.198	-.25	12.38
			13.7		58.14			.728			31.5	1.73									11.47
45	669	–	12.8	–	–	–	–	.736	–	–	2.74	3.05	66	.51	1.47	190	9.39	–	1.119	-.14	11.55
			13.8		–			.681			26.3	2.08									10.70
46	704	–	13.4	–	–	–	–	.769	–	–	3.56	3.97	86	.66	1.63	210	10.31	–	1.237	-.30	12.13
			14.5		–			.711			34.2	1.60									11.23

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE, 18½ ¢/LITER, 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE ±-FT	BHP UNCORRECT / (CORRECTED)	SUPPLY L/HR	RETURN FLOWMETERS / STANDPIPE L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT / (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # DIESEL # EQUIV.	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT / (CORRECTED)
	DAISEY DIESEL BOOSTER - REGULATOR @ 15"										H2O	-.128	ORIFICE (		COMPARED TO TEST			43			
47	575	100	11.0	52.73	48.66	4.06	7.59	.768	148	1.16	.74	.83	18	.14	1.30	166	8.42	81.1	.978	.03	11.82
			12.0		48.68			.701			7.1	9.16									10.79
															COMPARED TO TEST 31						
48	1210	100	23.0	108.97	102.49	7.48	13.97	.677	272	2.13	1.47	1.63	35	.27	2.40	308	15.60	93.9	1.062	-.13	10.43
			25.3		103.00			.617			14.1	8.54									9.50
															COMPARED TO TEST 35						
49	1016	100	19.4	92.98	86.68	6.31	11.78	.681	229	1.80	1.27	1.42	30	.24	2.03	260	13.19	90.6	1.028	.05	10.50
			21.3		86.77			.621			12.2	8.31									9.56
															COMPARED TO TEST 39						
50	835	100	15.9	76.13	71.05	5.08	9.49	.661	185	1.45	.93	1.03	22	.17	1.62	207	10.52	92.1	1.034	.05	10.18
			17.5		71.30			.602			8.9	9.17									9.27

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE, 18½ ¢/LITER, 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET FLOWMETER STANDPIPE L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # DIESEL # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT CORRECT
	CASEV DIESEL BOOSTER - REGULATOR @ 15" H_2O - .128 ORIFICE																				
51	1628	300	93	133.94	112.86	21.08	39.36	.423	767	6.01											6.46
			101.5			20.19		.388													5.92
52	1629	300	93.1	133.40	114.20	19.20	35.86	.422	699	5.47	3.05	3.39	73	.56	6.04	773	39.25	91.1	1.008	-.003	6.48
			101.6			18.20		.386			29.2	10.57									5.94
53	1780	300	101.7	136.44	113.77	22.67	42.34	.416	825	6.46											6.36
			111.1			21.14		.381													5.82
54	1728	300	104.4	137.08	116.16	20.92	39.07	.414	762	5.96	3.74	4.17	90	.69	6.66	582	43.24	92.3	1.003	-.19	6.37
			113.8			19.89		.380			35.9	9.37									5.85
55	2115	300	120.9	135.01	108.56	26.51	49.50	.410	965	7.55											6.25
			132.0			24.92		.375													5.72
56	2164	312	128.6	135.58	109.85	25.73	48.05	.407	937	7.33	3.91	4.35	94	.72	8.06	1032	52.40	97.1	1.069	-.50	6.26
			140.7			23.87		.372			37.4	11.04									5.73
57	2137	300	122.1	137.91	112.75	25.16	46.98	.421	916	7.17	3.94	4.39	95	.73	7.90	1012	51.37	94.9	1.048	-.35	6.47
			134.0			23.45		.383			37.6	10.70									5.90

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE, 18½ ¢/LITER, 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE FT-LB	BHP UNCORRECT / (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET FLOWMETER THROTTLE L/HR	NET #/HR	#/BHP-HR UNCORRECT / (CORRECTED)	NET (1000) BTU/HR	COST $/HR	L/HR (ft³/HR)	#/HR # DIESEL / # PROPANE	BTU/HR 1000X	COST $/HR	TOTAL FUEL COST $/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST $/HR	¢/BHP-HR UNCORRECT / CORRECT
		DAISEY		DIESEL BOOSTER -		REGULATOR @		15" H_2O	- .128		ORIFICE										
58	2233	300	127.6	125.56	95.93	29.62	55.32	.434	1078	5.44											6.62
			139.5			26.81		.396													6.05
59	2226	300	127.2	136.06	110.12	25.94	48.45	.417	944	7.39	4.08	4.54	98	.75	8.15	1043	52.99	87.6	.967	.30	6.41
			139.3			24.07		.380			39.1	10.67									5.85
60	2220	300	126.8	137.31	111.80	25.50	47.62	.411	928	7.27	4.09	4.56	99	.76	8.03	1028	52.18	86.1	.953	.42	6.33
			139.6			24.03		.374			39.2	10.45									5.75
61	2408	300	137.6	135.03	103.40	31.64	59.08	.429	1152	9.02											6.55
			146.9			29.95		.402													6.14
62	2439	312	144.9	130.78	100.92	29.87	55.77	.419	1087	8.51	4.41	4.92	107	.82	9.33	1195	60.69	94.4	1.037	-.31	6.44
			154.6			28.15		.393			42.3	11.34									6.03
63	2413	300	137.8	131.55	103.03	28.52	53.26	.422	1038	8.13	4.40	4.91	106	.81	8.94	1145	58.17	90.2	.994	.07	6.49
			147.5			26.87		.394			42.2	10.85									6.06

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE, 18½ ¢/LITER 21800 BTU/#

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT / (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET FLOWMETER STANDPIPE L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR # DIESEL = PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT CORRECTED
	DAISEY DIESEL BOOSTER - REGULATOR @ 15" H_2O - .128 ORIFICE																				
44	2237	300	127.8	106.15	76.77	29.39	54.87	.429	1070	8.38											6.55
			139.3			27.47		.394													6.01
55	2237	300	127.8	134.46	105.38	29.10	54.33	.425	1059	8.29											6.49
			139.5			27.11		.390													5.95
66	2218	300	126.7	132.54	106.72	25.83	48.23	.417	940	7.36	4.10	4.57	99	.76	8.12	1040	52.79	88.8	.901	.17	6.41
			138.7			23.78		.381			39.3	10.56									5.85

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE, 18½ ¢/LITER, 21800 BTU/#

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP (UNCORRECT) (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET (FLOWMETER STRAIGHTSIDE) L/HR	NET #/HR	#/BHP-HR (UNCORRECT) (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR (# DIESEL EQUIV)	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR (UNCORR) (CORR)
	DAISEY DIESEL BOOSTER - REGULATOR @ 15" H2O - .128 ORIFICE																				
67	2225	300	127.1	132.13	104.35	27.78	51.88	.408	1011	7.92											6.23
			137.5			27.03		.377													5.76
#68	—	—	127.1	133.48	105.65	27.83	51.96	.409	1013	7.93											6.24
			137.7					.377													5.76
69	—	—	—	132.71	105.06	27.72	51.76	.407	1009	7.90											6.21
			138.1			26.89		.375													5.72
70	—	—	—	133.91	105.98	27.93	52.15	.410	1017	7.96											6.26
			138.5			26.67		.377													5.75
71	—	—	—	134.02	107.25	26.78	50.00	.393	975	6.73											6.00
			138.4					.361													5.52
											COMPARED TO TEST # 68										
72	2280	312	135.5	132.18	104.95	27.23	50.85	.410	991	7.76	4.26	4.75	103	.79	8.55	1095	55.60	97.9	1.081	-.62	6.31
			147.4			26.21		.377			40.9	10.71									5.80

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE, 18½ ¢/LITER 21800 BTU/#,

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT / (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET (FLOWMETER, STROBOPHIL) L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # DIESEL # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT / CORRECT
	DAISEY DIESEL BOOSTER – REGULATOR @ 15" H_2O – .128 ORIFICE																				
73	2211	450	189.5	133.35	94.23	39.12	73.05	.386	1424	11.15											5.88
			203.6			37.86		.359													5.48
74	—	—	—	136.85	96.73	39.33	73.43	.385	1432	11.21											5.92
			203.4					.361													5.51
75	—	—	—	134.32	95.42	38.90	72.64	.383	1416	11.09											5.85
			203.2					.357													5.46
76	—	—	—	133.83	96.83	37.01	69.10	.365	1347	10.55											5.57
			201.8					.342													5.23
			AVERAGES			38.59	72.06		1405	11.00											
77	2283	472	205.2	130.30	92.53	37.77	70.52	.368	1375	10.76	4.51	5.02	109	.83	11.60	1485	75.54	97.9	1057	-.60	5.65
			218.5					.346			43.2	14.04									5.31
78	—	—	—	134.85	95.89	38.96	72.75	.379	1419	11.10	4.51	5.02	109	.83	11.94	1528	77.77	101.0	1.088	-.94	5.82
			219.6					.354			43.2	14.49									5.44
79	2275	—	204.5	116.98	76.96	39.12	73.05	.382	1424	11.15	4.47	4.98	108	.83	11.98	1533	78.03	101.4	1.091	-.98	5.86
			219.9					.355			42.8	14.68									5.45
80	2284	—	205.3	138.24	99.25	38.98	72.79	.381	1419	11.11	4.79	5.33	116	.89	12.°C	1536	78.13	101.0	1.093	-1.00	5.84
			220.9			38.35		.354			45.9	13.65									5.43

DIESEL 28½ ¢/L 19505 BTU/# 859 KG/m³ PROPANE 18½ ¢/L 21800 BTU/#

ENGINE LOAD				DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE		DIESEL-PROPANE/DIESEL				
RPM	TORQUE #-FT	BHP (UNCOR.)	BHP CORR.	SUPPLY L/HR	RETURN L/HR	NET L/HR FLOW METER CALIBRATED	#/HR	#/BHP-HR USING CORRECT BHP & CORR.	BTU/HR (1000)	COST/HR	L/HR ft³/HR.	#/HR. # DIESEL & PROPANE	BTU/HR (1000)	COST/HR	TOTAL COST PER HR	BTU/HR. (1000)	% DIESEL	RATIO OF BTU'S	SAVING IN FUEL COST	#/BHP-HR UNCORRECTED CORRECTED	TEST NO.
	DAISEY DIESEL BOOSTER - REGULATOR @ 15" H₂O - .128 ORIFICE																				
1595	300	91.2	97.6	129.80	109.39	20.41	38.12	.418	743	5.82										6.38	B1
						19.47		.390												5.96	
1610	300	92.0	98.5	129.37	110.47	18.90	35.30	.417	688	5.39	2.78	3.10	67	.51	5.90	756	92.6	1.017	.08	6.41	B2
						18.24		.390			26.7	11.39				38.40				5.99	
2042	320	124.4	133.3	131.73	105.75	25.98	48.52	.390	946	7.40										5.95	B3
						26.22		.364												5.56	
2070	328	129.3	139.4	134.93	113.23	21.70	40.53	.351	790	6.19	4.42	4.92	107	.82	7.00	897	83.5	.949	.40	5.42	B4
						22.28		.326			42.3	8.24				45.45				5.02	
2350	296	132.4	141.9	132.82	102.71	30.05	56.11	.424	1094	8.56										6.47	B5
								.395												6.09	
2386	300	136.3	144.7	129.33	102.25	27.08	50.56	.419	986	7.72	5.83	6.49	141	1.08	8.80	1127	90.1	1.031	-.23	6.45	B6
						26.06		.394			55.9	7.79				57.06				6.08	

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE. 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT / (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT / (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # WHEEL / # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT / CORRECTED
	DAISEY DIESEL BOOSTER - REGULATOR @ 32.2 " H_2O - .128 NOZZLE - METERING VALVE WIDE OPEN																				
87	807	100	15.4	74.77	69.83	4.94	9.22	.600	179	1.41											9.15
			16.4					.561													8.56
88	950	120	21.7	87.78	85.39	2.39	4.47	.582	87	.68	7.34	5.18	78	1.36	2.04	265	12.64	48.5	1.476	-.63	9.39
			23.3					.544			70.4	.55									8.77
89	806	100	15.4	70.56	68.87	1.69	3.15	.740	61	.48	7.38	8.22	179	1.37	1.85	240	11.37	34.1	1.338	-.44	12.02
			16.4					.691			70.7	.38									11.23
90	2379	300	135.9	133.68	102.96	30.72	57.36	.422	1118	8.76											6.44
			146.4					.392													5.98
91	2415	308	141.6	134.29	106.79	27.55	51.44	.426	1003	7.85	7.95	8.86	153	1.47	9.32	1196	60.30	89.7	1.069	-.57	6.58
			150.3					.401			76.2	5.81									6.20
92	—	—	—	107.00	80.59	26.91	50.25	.417	980	7.67	—	—	—	—	9.14	1173	59.11	87.6	1.049	-.39	6.45
			149.9					.394			—	—									6.10
93	2384	300	136.2	134.80	108.82	25.98	48.51	.421	946	7.40	7.92	8.82	192	1.47	8.87	1138	57.34	84.6	1.018	-.11	6.51
			145.2					.395			75.9	5.50									6.11

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE, 18½ ¢/LITER 21800 BTU/#

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT / (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT / (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR ± DIESEL ± PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT / CORRECTED
	DAISEY DIESEL BOOSTER - REGULATOR @ 32 2" H_2O - .128 NOZZLE - NO METERING VALVE																				
94	2383	300	136.1	136.18	110.94	25.24	47.13	.415	919	7.19	8.44	9.40	204	1.56	8.75	1124	56.52	82.2	1.005	00	6.43
			144.7					.391			80.9	5.01									6.05
	DAISEY DIESEL BOOSTER - REGULATOR @ 32 2" H_2O - NO NOZZLE + NO METERING VALVE																				
95	2386	300	136.3	136.25	112.00	24.25	45.28	.424	883	6.91	11.17	12.45	271	2.07	8.98	1154	57.73	78.9	1.032	-.22	6.59
			146.1					.395			107.1	3.64									6.15

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE. 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # DIESEL # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-H UNCORRECT CORRECTED
	DAISEY DIESEL BOOSTER - REGULATOR @ 5 PSI - NO NOZZLE - NO METERING VALVE																				
96	2381	300	136	132.9	102.37	30.53	57.91	.417	1112	8.70											6.40
			142.9					.399													6.09
97	2343	300	136.7	129.24	95.75	31.49	58.75	.430	1146	8.97											6.56
			144.9					.407													6.21
						31.52	58.77		1123	8.99											
98	2393	300	136.7	130.59	99.03	31.56	58.94	.431	1149	9.00											6.58
			144.5					.408													6.22
99	2485	320	151.4	123.41	106.97	21.44	40.04	.419	780	6.11	21.09	23.49	512	3.90	10.01	1293	63.52	67.9	1.125	-1.02	6.61
			159.9					.397			202.1	1.70									6.26
100	2377	300	135.8	132.03	114.01	18.02	33.65	.419	656	5.14	20.85	23.23	506	3.86	8.99	1162	56.87	57.1	1.011	.00	6.62
			146.9					.387			199.9	1.45									6.12
	DAISEY DIESEL BOOSTER - REGULATOR SET @ 20 PSI - NO NOZZLE - NO METERING VALVE																				
101	2393	300	136.7	130.67	113.24	17.43	32.54	.417	634	4.87	21.95	24.45	533	4.06	9.03	1167	56.99	55.2	1.016	-.03	6.60
			148.2					.385			216.4	1.33									6.09
	DIESEL FUEL CONSUMPTION NOT MEASURED - TEST # 101 DIESEL CONSUMPTION ASSUMED (ACTUALLY WOULD BE LESS)																				
102	2397	300	137.0	—	—	—	—	.478	—	—	29.55	32.92	717	5.47	10.43	1352	65.46	55.2	1.177	-1.43	7.62
			148.8					.440			253.3	.99									7.01

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE, 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT / (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT / (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR # DIESEL / # FUEL	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT / CORRECT.
	UNSEY DIESEL BOOSTER - REGULATOR @ 15" H_2O - .128 ORIFICE																				
103	2373	300	135.8	131.48	99.40	32.07	59.89	.441	1168	9.14											6.73
			145.1					.413													6.30
104	2357	372	169.1	132.76	99.43	33.33	62.24	.409	1213	9.50	6.27	6.98	152	1.16	10.66	1366	69.22	103.9	1.170	-.52	6.30
			179.9					.385			60.1	8.91									5.93
105	2354	360	161.4	133.16	97.19	35.97	67.17	.416	1310	10.25											6.35
			171.4					.392													5.98
106	2390	300	136.5	134.30	103.02	31.28	58.41	.428	1139	8.92											6.53
			147.2					.397													6.06
107	2385	352	159.9	132.48	100.42	32.07	59.88	.416	1167	9.14	6.21	6.92	150	1.15	10.29	1318	66.80	102.5	1.158	-1.37	6.43
			171.9					.389			59.6	8.65									5.99
108	2385	352	159.9	133.09	101.51	31.59	58.99	.412	1150	9.00	6.21	6.92	150	1.15	10.15	1301	65.91	101.0	1.143	-1.23	6.35
			171.5					.384			59.6	8.52									5.92

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE. 18½ ¢/LITER, 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP (INCORRECT) / (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR (INCORRECT) / (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # DIESEL / # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR (INCORRECT) / (CORRECT)
	DAISEY DIESEL BOOSTER - REGULATOR @ 15" H₂O - .128 NOZZLE																				
109	2379	300	135.9	129.79	98.27	31.13	58.12	.428	1133	8.87											6.53
			145.2					.400													6.11
110	2394	300	136.8	129.15	97.35	31.80	59.38	.434	1158	9.06											6.63
			146.1					.406													6.20
11	—	—	—	132.84	101.11	31.83	59.43	.435	1159	9.07											6.63
			146.3					.406													6.20
			AVERAGES =				58.98		1150	9.00											
112	2388	348	158.3	130.55	99.26	31.30	58.44	.415	1139	8.92	6.48	7.21	157	1.20	10.12	1297	65.65	99.1	1.128	-1.12	6.39
			168.5					.390			62.1	8.10									6.00
113	2391	348	—	131.26	100.26	30.99	57.87	.409	1128	8.83	6.30	7.02	153	1.17	10.00	1281	64.90	98.1	1.115	-1.00	6.31
			—					.385			60.4	8.24									5.93

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE 18½ ¢/LITER, 21800 BTU/#

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE ≠-FT	BHP UNCORRECT / (CORRECT)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECT)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR ≠ DIESEL ≠ PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT / CORRECT
	DAISEY DIESEL BOOSTER - REGULATOR @ 15" H_2O - .128 NOZZLE																				
114	2389	400	182.0	133.17	93.11	40.06	74.80	.411	1458	11.42											6.27
			191.7					.390													5.96
115	2397	440	200.8	131.81	91.05	40.77	76.13	.416	1484	11.62	6.67	7.43	161	1.23	12.85	1646	83.56	101.8	1.129	-1.44	6.40
			211.8					.394			63.9	10.25									6.07
116	—	—	—	133.03	93.75	39.28	73.35	.402	1430	11.20	6.63	7.39	161	1.23	12.42	1591	80.74	98.1	1.091	-1.01	6.19
			212.0					.381			63.6	9.93									5.86
117	2381	452	204.8	133.66	93.95	39.71	74.15	.397	1446	11.32	6.47	7.21	157	1.20	12.52	1603	81.36	99.1	1.089	-1.10	6.11
			216.2					.376			62.0	10.28									5.79
	DAISEL DIESEL BOOSTER - REGULATOR @ 15" H_2O - .110 NOZZLE																				
118	2384	444	201.6	134.17	94.36	39.82	74.35	.399	1450	11.35	5.45	6.08	132	1.01	12.36	1582	80.43	99.4	1.085	-.94	6.13
			213.4					.377			52.3	12.24									5.79
119	2379	400	181.2	135.68	96.54	39.14	73.09	.403	1425	11.16											6.16
			183.6					.377													5.76
120	2382	400	181.4	135.36	99.19	36.17	67.55	.405	1317	10.31	5.39	6.00	130	1.00	11.31	1448	73.55	92.4	1.016	-.15	6.23
			194.9					.377			51.7	11.25									5.80

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 847 KG/M³, PROPANE. 18½ ¢/LITER 21,800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR # DIESEL # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT CORRECT
		METERING TUBE 3-36																			
181	1401	0	0	128.20	123.46	4.74	8.65	—	172	1.35	2.31	2.57	56	.43	1.78	228	11.42				—
			0		123.86			—			22.1	3.45									—
		DIESEL ONLY																			
182	1575	0	0	135.52	128.94	6.57	12.27	—	239	1.87											—
			0		127.88			—													—
		METERING TUBE 3-36																			
183	1586	0	0	131.65	126.11	5.54	10.34	—	201	1.58	2.89	3.16	68	.52	2.10	270	13.50	84.3	1.130	-.23	—
			0		129.12			—			27.2	3.27									—
		DIESEL ONLY																			
184	1802	0	—	137.10	129.75	7.35	13.73	—	267	2.10											—
			—		125.94			—													—
		DIESEL ONLY																			
185	1839	0	—	134.83	126.57	8.26	15.42	—	300	2.35											—
			—		130.11																—
		METERING TUBE 3-36																			
186	1816	0	—	132.20	124.90	7.30	13.62	—	265	2.08	3.16	3.52	76	.58	2.66	342	17.14	88.3	1.138	-.31	—
			—		130.44			—			30.3	3.87									—

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 847 KG/M³, PROPANE, 18½ ¢/LITER 21800 BTU/#

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # DIESEL / # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT CORRECTED
		DIESEL ONLY																			
187	1998	0	—	138.87	106.12	32.75	61.16	—	1192	9.33											—
			—		129.84			—													—
		METERING TUBE 3-36																			
188	1966	0	—	136.29	106.16	30.12	56.25	—	1097	8.58	3.42	3.81	83	.63	9.22	1180	60.05	92.0	.989	.12	—
			—		127.51			—			32.8	14.77	—								—
		DIESEL ONLY																			
189	2197	0	—	138.48	130.05	8.43	15.75	—	307	2.40											—
			—		133.07			—													—
		METERING TUBE 3-36																			
190	2200	0	—	139.17	128.34	10.83	20.22	—	394	3.09	3.71	4.13	89	.69	3.77	484	24.35	128.4	1.577	-1.37	—
			—		131.87			—			35.5	4.40									—
		DIESEL ONLY																			
191	2369	0	—	138.05	125.24	12.80	23.91	—	466	3.65											—
			—		124.70			—													—
		METERING TUBE 3-36																			
192	2366	0	—	140.85	129.73	11.12	20.77	—	405	3.17	4.39	4.89	106	.81	3.98	511	25.65	86.9	1.097	-.33	—
			—		129.35			—			42.0	4.25									—

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 : BTU/#, 859 KG/M³, PROPANE, 18½ ¢/LITER, 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE FT-FT	BHP UNCORRECT / (CORRECTED)	SUPPLY L/HR	RETURN (FLOWMETERS STANDARDIZED) L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT / (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # DIESEL # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-H UNCORRECT. / CORRECTED
		DIESEL		ONLY																	
201	1589	100	30.3	133.71	122.73	10.98	20.49	.677	399	3.13											
			32.9		123.01			.623													10.34
		DIESEL		ONLY																	9.51
202	—	—	—	134.21	123.48	10.72	20.03	.662	390	3.06											
			—		125.27			.609													10.10
			AVERAGES =				20.26		395	3.10											9.29
		METERING TUBE 3-36																			
203	1592	100	30.3	132.78	124.23	8.55	15.96	.655	311	2.44	3.50	3.90	85	.65	3.08	396	19.86	78.8	1.003	.02	10.17
			33.0		125.54			.602			33.6	4.09									9.34
		METER TUBE 5-36																			
204	1585	100	30.2	130.13	122.53	7.61	14.20	.660	277	2.17	5.15	5.74	125	.95	3.12	402	19.94	70.1	1.018	-.02	10.34
			33.0		125.54			.605			49.4	2.48									9.47
		METER TUBE 9-36																			
205	1608	100	30.6	131.57	124.78	6.79	12.69	.733	247	1.94	8.77	9.77	212	1.62	3.56	460	22.45	62.6	1.166	-.46	11.62
			33.3		126.48			.675			84.0	1.30									10.69

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE, 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE FT-LB	BHP UNCORRECT / (CORRECTED)	SUPPLY L/HR	RETURN FLOWMETER HR / STANDPIPE L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT / (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR # DIESEL # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECTED / CORRECTED
		DIESEL ONLY																			
206	1984	100	37.8	135.67	122.67	13.00	24.27	.642	473	3.70											
			41.2		125.40			.589													9.80
																					8.99
		METERING TUBE 3-36																			
207	1980	100	37.7	137.34	126.39	10.95	20.44	.671	398	3.12	4.36	4.86	105	.81	3.93	504	25.30	84.2	1.066	-.22	10.41
			41.1		130.08			.615			41.8	4.21									9.55
		METERING TUBE 5-36																			
208	1987	100	37.8	135.24	125.22	10.02	18.71	.688	364	2.86	6.56	7.30	159	1.21	4.07	524	26.01	77.1	1.107	-.36	10.75
			41.6		130.49			.626			62.8	2.56									3.79
		METERING TUBE 9-36																			
209	2002	100	38.1	133.86	124.60	9.26	17.29	.755	337	2.64	10.33	11.51	250	1.91	4.55	588	28.79	71.2	1.242	-.85	11.93
			41.6		125.80			.692			99.0	1.50									10.94

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE. 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECT)	SUPPLY L/HR	RETURN FLOW METER STANDPIPE L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR % DIESEL & PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-H UNCORRECT CORRECT
		DIESEL ONLY																			
210	2370	100	45.1	136.92	121.28	15.65	29.22	.647	569	4.46											
			49.1		121.85			.595													9.88
		METERING TUBE				3-36															9.08
211	2362	100	45.0	138.94	125.39	13.55	25.31	.688	493	3.86	5.05	5.62	122	.93	4.80	616	30.93	86.6	1.081	-.34	10.67
			49.0		128.05			.631			48A	4.50									9.78
		METERING TUBE				5-36															
212	2381	100	45.3	131.55	118.78	12.77	23.85	.717	465	3.64	7.77	8.66	188	1.44	5.08	653	32.51	81.6	1.147	-.62	11.20
			49.8		118.99			.653			74.5	2.76									10.19
		METERING TUBE				9-36															
213	2386	100	45A	136.36	124.17	12.19	22.76	.752	443	3.47	10.22	11.39	248	1.89	5.36	692	34.15	77.9	1.215	-.91	11.81
			49.8		126.23			.685			98.0	2.00									10.77

FUEL DATA → DIESEL 28 1/2 ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE, 18 1/2 ¢/LITER 21800 BTU/#

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE M-FT	BHP (CORRECTED)	SUPPLY L/HR	RETURN (FLOWMETER) STAND PIPE L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR % DIESEL % PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT. CORRECTED
		DIESEL		ONLY																	
214	1582	200	60.3	133.18	117.47	15.71	29.33	.487	572	4.48											
			66.4		117.61			.491													7.43
		METERING		TUBE	3-36																6.74
215	1594	200	60.7	131.82	118.31	13.51	25.23	.481	492	3.85	3.55	3.95	86	.66	4.51	578	29.18	86.0	1.011	.03	
			67.2		120.13			.434			34.0	6.39									7.42
																					6.71
		DIESEL		ONLY																	
216	1979	200	75.4	137.59	117.93	19.66	36.71	.487	716	5.60											
			83.1		117.85			.442													7.43
		METERING		TUBE	3-36																6.74
217	1985	200	75.6	138.23	121.25	16.98	31.71	.487	618	4.84	4.59	5.12	111	.85	5.69	730	36.83	86.4	1.020	.09	
			83.7		123.41			.440			44.0	6.20									7.52
																					6.80
		DIESEL		ONLY																	
218	E468	208	97.8	136.65	111.86	24.79	4630	.474	903	7.07											
			186.7		114.63			.434													7.23
		METERING		TUBE	3-36																6.62
219	2355	200	89.7	138.57	118.56	20.01	37.36	.488	728	5.70	5.75	6.41	139	1.06	6.77	868	43.76	80.7	.962	.30	
			97.6		120.50			.449			55.1	5.83									7.54
																					6.94

FUEL DATA → DIESEL 28 1/2 ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE, 18 1/2 ¢/LITER, 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT / (CORRECTED)	SUPPLY L/HR	RETURN FLOWRITE STANDPIPE L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR = DIESEL + PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT. / CORRECTED
		DIESEL		ONLY																	
220	1594	300	91.1	130.94	110.14	20.80	38.84	.426	757	5.93											
			99.8		110.46			.389													6.51
		METERING		TUBE	3-36																5.94
221	1600	300	91.4	131.21	113.28	17.93	33.48	.412	653	5.11	3.74	4.17	90	.69	5.80	744	37.65	66.2	.982	.12	6.35
			100.1		114.94			.376			35.9	8.03									5.79
		METERING		TUBE	5-36																
222	1609	300	91.9	130.04	112.61	17.43	32.55	.427	634	4.97	5.99	6.67	145	1.11	6.08	780	39.22	83.8	1.030	-.15	6.61
			101.2		115.16			.387			57.4	4.88									6.00
		METERING		TUBE	9-36																
223	1609	300	91.9	131.22	115.91	15.31	28.59	.428	557	4.36	9.67	10.77	234	1.79	6.15	792	39.36	73.6	1.046	-.22	6.69
			100.8		112.41			.391			92.7	2.65									6.10
		DIESEL		ONLY																	
224	1836	312	109.1	135.34	111.33	24.01	44.84	.411	874	6.84											6.27
			119.5		112.02			.375													5.73
		METERING		TUBE	3-36																
225	1791	300	102.4	134.36	111.89	22.47	41.95	.459	818	6.40	4.50	5.01	109	.83	7.23	927	46.96	93.6	1.060	-.39	7.07
			111.8		116.47			.420			43.1	8.38									6.47

FUEL DATA → DIESEL 28 1/2 ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE. 18 1/2 ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE FT-LB	BHP (UNCORRECT) (CORRECTED)	SUPPLY L/HR	RETURN (FLOW METER) (GRAVIMETRIC) L/HR	NET L/HR	NET #/HR	#/BHP-HR (UNCORRECT) (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	¢/HR (FT³/HR)	#/HR (% DIESEL OF TOTAL)	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR (UNCORRECT) (CORRECTED)
		DIESEL	ONLY																		
226	1948	300	111.3	139.07	114.21	24.86	46.42	.417	905	7.08											6.37
			122.4		120.14			.379													5.79
		METERING	TUBE	3-36																	
227	1992	300	113.8	138.64	115.85	22.79	42.55	.424	829	6.49	5.12	5.71	.124	.95	7.44	954	48.26	91.7	1.054	-.36	6.54
			126.0		116.90			.383			49.1	7.46									5.91
		METERING	TUBE	5-36																	
228	1940	292	107.9	136.16	115.95	20.21	37.74	.423	736	5.76	7.13	7.34	173	1.32	7.08	909	45.68	81.3	1.004	.01	6.56
			120.2		118.98			.380			68.4	4.75									5.89
		METERING	TUBE	9-36																	
229	1932	300	110.4	137.18	118.46	18.71	34.94	.420	681	5.33	10.26	11.43	249	1.90	7.23	930	46.37	75.3	1.028	-.15	6.55
			122.0		118.13			.380			98.3	3.06									5.93

DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE. 18½ ¢/LITER 21800 BTU/#.

ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
RPM	TORQUE #-FT	BHP UNCORRECT / (CORRECTED)	SUPPLY L/HR	RETURN FLOWMETERS STANDPIPE L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT / (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # [illegible]	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-H UNCORRECT / CORRECTE
	DIESEL	ONLY																		
2369	300	135.4	135.74	104.64	31.10	58.07	.429	1132	8.86											
		145.9		105.06			.398													6.55 / 6.07
	METERING		TUBE 3-36																	
2364	300	135.1	137.25	108.73	28.52	53.25	.447	1038	8.13	6.44	7.18	156	1.19	9.32	1195	60.93	91.7	1.055	-.46	6.90
		147.1		110.62			.411			61.8	7.42									6.34
	METERING		TUBE 5-36																	
2382	300	136.1	133.93	108.86	25.06	46.80	.422	912	7.14	9.50	10.58	230	1.76	8.90	1143	57.38	80.6	1.010	-.04	6.54
		148.8		110.04			.386			91.1	4.42									5.98
	METERING		TUBE 9-36																	
2389	300	136.5	136.08	110.83	25.25	47.15	.428	919	7.20	10.13	11.29	246	1.87	9.07	1165	58.44	81.2	1.029	-.21	6.65
		150.5		113.72			.388			97.1	4.18									6.03

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE, 18½ ¢/LITER, 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECT)	SUPPLY L/HR	RETURN FLOWMETERS STANDPIPE L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR # DIESEL + PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-H UNCORRECT CORRECTE
		DIESEL	ONLY																		
234	1579	500	150.4	128.58	95.17	34.41	64.26	.427	1253	9.81											
			167.8		58.41			.383													6.52
																					5.85
		METERING TUBE 3-36																			
235	1588	500	151.3	140.98	101.27	39.71	74.15	.525	1446	11.32	4.72	5.26	114	.87	12.19	1560	79.41	115.4	1.245	-2.38	8.06
			170.1		102.40			.467			45.3	14.10									7.17
		METERING TUBE 5-36																			
236	1607	500	153.1	130.09	100.39	29.69	55.45	.413	1081	8.46	7.03	7.84	170	1.30	9.76	1252	63.28	86.3	.999	.04	6.38
			169.9		101.11			.372			67.4	7.08									5.75
		METERING TUBE 9-36																			
237	1591	500	151.5	132.91	104.51	28.40	53.02	.425	1034	8.09	10.28	11.45	249	1.90	9.99	1283	64.48	82.5	1.024	-.19	6.60
			167.5		102.87			.385			98.6	4.63									5.97

FUEL DATA → DIESEL 28 1/2 ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE, 18 1/2 ¢/LITER, 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECTED)	SUPPLY L/HR	RETURN FLOWMETERS STANDPIPE L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR # DIESEL # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECTED CORRECTED
		DIESEL ONLY																			
238	1978	500	188.4	133.74	93.38	40.36	75.37	.400	1470	11.50											
			211.6		92.39			.356													6.11
		METERING TUBE 3-36																			5.44
239	1972	500	187.8	135.01	99.06	35.95	67.13	.395	1309	10.25	6.31	7.03	153	1.17	11.41	1462	74.16	89.1	.995	.09	6.08
			208.5		99.27			.356			60.5	9.55									5.47
		METERING TUBE 5-36																			
240	2000	500	190.5	135.35	101.22	34.13	63.73	.388	1243	9.73	9.17	10.21	222	1.70	11.42	1465	73.94	84.6	.997	.08	6.00
			212.8		105.87			.347			87.9	6.24									5.37
		METERING TUBE 9-36																			
241	2000	500	190.4	136.10	102.58	33.52	62.59	.358	1220	9.55	10.17	11.33	247	1.85	11.44	1467	73.93	83.1	.999	.07	6.00
			211.3		104.02			.350			97.5	5.52									5.41

FUEL DATA → DIESEL 28 1/2 ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE, 18 1/2 ¢/LITER 21800 BTU/#

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECTED)	SUPPLY L/HR	RETURN FLOWMETERS STANDPIPE L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR # DIESEL # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT (CORRECTED)
		DIESEL ONLY																			
242	2372	500	225.9	139.60	91.65	47.95	83.53	.396	1746	13.66											
			249.4		91.17			.366													6.05
																					5.59
		METERING TUBE 3-36																			
243	2364	500	225.1	138.80	96.17	42.63	79.60	.393	1552	12.15	7.53	8.84	192	1.47	13.62	1745	88.44	88.9	.999	.05	6.05
			243.3		97.01			.364			76.1	9.01									5.60
		METERING TUBE 5-36																			
244	2374	500	226.1	138.01	96.13	41.88	78.20	.396	1525	11.94	10.07	11.22	244	1.86	13.80	1769	89.42	87.3	1.014	-.13	6.10
			238.1		96.25			.376			96.5	6.97									5.80
		METERING TUBE 9-36																			
245	2387	500	227.3	137.81	96.19	41.62	77.72	.392	1515	11.86	10.16	11.32	246	1.88	13.74	1762	89.03	86.8	1.009	-.08	6.04
			240.5		95.38			.370			97.4	6.87									5.71

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³, PROPANE, 18½ ¢/LITER, 21800 BTU/#

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT / (CORRECTED)	SUPPLY L/HR	RETURN (FLOW RATE THROUGH PT) L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT / (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR (# DIESEL # EQUIVALENT)	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT / (CORRECTED)
		METERING	TUBE	9-36	- @	90°	→	○		HOLES	COMPARED TO TEST NO. 230										
246	2382	300	36.1	137.31	112.00	25.31	47.27	.430	921	7.21	10.16	1.32	246	1.88	9.09	1168	58.58	81.4	1.032	-.23	6.68
			51.4		112.04			.387			97.4	4.18									6.00
		METERING	TUBE	- OPEN	END		→	▽			COMPARED TO AVERAGES OF TEST NOS 201 & 202										
247	1600	100	30.5	131.83	126.03	5.80	10.84	.728	211	1.65	10.20	11.36	247	1.89	3.54	459	22.20	53.5	1.162	-.44	11.62
			33.5		125.50			.663			97.8	.95									10.58
		METERING	TUBE	- OPEN	END	- 45°	CUT PARALLEL TO FLOW (IE SIDEWAYS)														
248	1598	100	30.4	132.42	126.81	5.61	10.47	.718	204	1.60	10.22	11.38	248	1.89	3.49	452	21.85	51.7	1.145	-.39	11.46
			33.5		128.46			.652			97.9	.92									10.41
		SAME	AS	248							COMPARED TO TEST NO 206										
249	2002	100	38.1	136.98	127.35	8.74	16.31	.726	318	2.49	10.21	11.37	247	1.89	4.38	566	27.69	67.2	1.197	-.68	11.48
			42.1		129.41			.658			97.9	1.43									10.41
		SAME	AS	246							COMPARED TO TEST NO. 210										
250	2392	100	45.5	137.08	125.11	11.97	22.35	.739	435	3.41	10.16	11.31	246	1.88	5.29	682	33.67	76.5	1.200	-.83	11.62
			50.4		125.66			.668			97.4	1.98									10.50

FUEL DATA → DIESEL 28½ ¢/LITER, 19505 BTU/#, 859 KG/M³; PROPANE, 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT / (CORRECTED)	SUPPLY L/HR	RETURN FLOWMETER STANDPIPE L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT / (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR # DIESEL / # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP UNCORR / CORREC
	METERING TUBE - OPEN END →							↓			COMPARED TO TEST NO. 220										
251	1593	300	91.0	(31.38	116.46	14.92	27.86	.430	543	4.25	10.14	11.30	246	1.88	6.13	789	39.16	71.7	1.043	-.20	6.73
			100.3		118.95			.391			97.3	2.47									6.11
		DIESEL ONLY																			
252	989	200	37.5	30.23	80.03	10.19	19.04	.508	371	2.91											7.75
			40.4		80.36			.471													7.18
	SAME AS 251																				
253	972	200	37.0	89.12	85.56	3.57	6.66	.511	129	1.02	11.00	12.25	267	2.04	3.05	397	18.91	35.0	1.069	-.15	8.24
			40.0		85.77			.472			105.5	.54									7.62
	SAME AS 251																				
254	997	200	380	30.93	81.34	9.59	17.91	.602	349	2.73	4.44	4.95	107	.82	3.55	457	22.86	94.1	1.231	-.65	9.36
			41.3		82.98			.554			42.6	3.62									8.6

FUEL DATA → DIESEL 28½ ¢/LITER, 19367 BTU/#, 863 KG/M³, PROPANE, 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE FT-LB	BHP (UNCORRECT) (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR (UNCORRECT) (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR #DIESEL & PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR (UNCORRECT) (CORRECT)
		DIESEL ONLY																			
260	2394	300	136.8	96.76	65.11	31.64	59.08	.432	1,144	9.02											6.59
			145.4					.406													6.20
		DIESEL ONLY																			
261	2385	300	136.3	99.94	75.95	23.99	44.79	.329	867	6.84											5.02
			141.4					.317													4.83
		Y'D CARBURETOR (IMPCO 425)																			
262	2398	300	137.0	101.63	79.14	22.49	42.00	.427	813	6.41	14.85	16.54	360	2.75	9.16	1174	58.54	71.1	1.026	-.14	6.68
			146.6					.399			142.4	2.54									6.25
		DIESEL ONLY - THROTTLE PLATE ON Y'D CARBURETOR HELD CLOSED																			
263	1807	300	103.3	98.76	75.41	23.35	43.60	.422	844	6.65											6.44
			111.0					.393													6.00
		Y'D CARBURETOR (IMPCO 425)																			
264	1809	300	103.3	98.27	80.66	17.61	32.88	.415	636	5.02	8.97	9.99	217	1.66	6.68	854	42.87	75.4	1.012	-.02	6.46
			111.2					.385			8.0	3.29									6.00

FUEL DATA → DIESEL 28½ ¢/LITER, 19367 BTU/#, 863 KG/M³, PROPANE. 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR # DIESEL / # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP UNCORR (CORR)
		DIESEL ONLY																			
266	2385	300	136.2	133.70	102.00	31.70	59.20	.434	1146	9.03											6.63
			146.0					.405													6.19
		Y'D	CARBURETOR (IMPCO 425)																		
267	2400	300	137.1	134.53	111.98	22.35	41.73	.424	808	6.37	14.73	16.41	357	2.73	9.10	1166	58.14	70.5	1.017	-.06	6.63
			147.7					.394			141.2	2.54									6.16
		Y'D	CARBURETOR (IMPCO 425) - LIQUID PROPANE TO VAPORIZER																		
268	2387	300	136.4	99.36	81.66	17.70	33.05	.420	640	5.04	21.78	24.27	529	4.03	9.07	1169	57.32	55.8	1.020	-.04	6.66
			148.4					.386			208.8	1.36									6.11
		DIESEL ONLY																			
269	2405	200	91.6	103.91	79.79	24.12	45.04	.492	872	6.87											7.56
			99.8					.451													6.85
		Y'D	CARBURETOR (IMPCO 425) - LIQUID PROPANE TO VAPORIZER																		
270	2395	200	91.2	136.57	123.34	13.23	24.71	.494	478	3.77	18.24	20.32	443	3.37	7.15	921	45.03	54.9	1.056	-.27	7.83
			99.3					.454			174.9	1.22									7.20

FUEL DATA → DIESEL 28½ ¢/LITER, 19367 BTU/#, 863 KG/M³, PROPANE 18½ ¢/LITER 21800 BTU/#

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT / (CORRECT)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT / (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # DIESEL / # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECTED CORRECTED
		DIESEL	ONLY																		
271	2393	100	45.6	137.81	121.13	16.68	31.15	.684	603	4.75											
			49.5					.629													10.43
																					9.60
		Y'D	CARBURETOR (IMPCO 425)																		
272	2383	100	45.4	97.39	87.63	9.76	18.23	.796	353	2.78	16.05	17.88	389	2.97	5.75	472	36.11	58.5	1.231	-1.00	12.67
			49.3					.732			153.9	1.02									11.66
		Y'D	CARBURETOR (IMPCO 425)																		
273	2377	100	45.3	98.85	89.50	9.35	17.46	.812	338	2.67	17.33	19.30	420	3.21	5.87	759	36.76	56.1	1.258	-1.12	12.97
			49.0					.750			166.1	.90									11.98
		DIESEL	ONLY																		
274	1809	100	34.4	134.33	123.77	10.56	15.72	.573	381	3.01											8.74
			37.3					.529													8.07
		Y'D	CARBURETOR (IMPCO 425)																		
275	1804	100	34.3	136.01	126.52	9.49	17.72	.637	343	2.70	3.71	4.14	90	.69	3.39	433	21.86	89.9	1.135	-.38	9.89
			37.2					.588			35.6	4.28									9.12

FUEL DATA → DIESEL 28½ ¢/LITER, 19367 BTU/#, 863 KG/M³, PROPANE. 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP (UNCORRECT) (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR (UNCORRECT) (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # DIESEL # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR (UNCORR) (CORR)
		DIESEL	ONLY																		
276	1810	100	34.5	119.66	108.34	11.31	21.12	.613	409	3.22											9.3
			37.2					.568													8.6
		Y'D	CARBURETOR (IMPCO 425)																		
277	1803	100	34.3	90.84	83.22	7.62	14.23	.673	275	2.17	7.98	8.89	193	1.48	3.65	469	23.12	67.4	1.148	-.42	10.6
			37.1					.623			76.5	1.60									9.8
		DIESEL	ONLY																		
278	2387	100	45.5	124.96	108.89	16.07	30.01	.660	581	4.58											10.0
			49.3					.609													9.3
		Y'D	CARBURETOR (IMPCO 425)																		
279	2387	100	45.5	95.10	85.68	9.42	17.58	.800	340	2.68	16.87	18.80	409	3.12	5.80	750	36.38	58.6	1.291	-1.22	12.7
			49.4					.737			161.8	.94									11.7
		DIESEL	ONLY																		
280	2386	300	136.3	102.46	71.30	31.15	58.17	.427	1126	8.88											6.5
			146.0					.398													6.0
		Y'D	CARBURETOR (IMPCO 425)																		
281	2372	300	135.5	97.87	81.00	16.87	31.50	.417	610	4.81	22.41	24.97	544	4.15	8.95	1154	56.46	54.1	1.025	-.07	6.61
			147.6					.383			214.9	1.26									6.07

FUEL DATA → DIESEL 28 1/2 ¢/LITER, 19367 BTU/#, 863 KG/M³, PROPANE. 18 1/2 ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP (CORRECT)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR (CORRECT)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR # DIESEL # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR (CORRECT)
		DIESEL ONLY																			
282	2387	444	201.8	105.56	61.96	43.60	81.41	.403	1576	12.43											6.16
			211.9					.384													5.86

FUEL DATA → DIESEL 285 ¢/LITER, 19367 BTU/#, 863 KG/M³, PROPANE. 18.5 ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE LB-FT	BHP (UNCORRECT) (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR (UNCORRECT) (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (CM³/HR)	#/HR (% DIESEL & PROPANE)	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR (CORRECTED)
		DIESEL ONLY																			
283	2508	480	229.3	132.58	82.34	50.25	93.83	.409	1817	14.32											6.25
			238.5					.393													6.00
		Y'D CARBURETOR (IMPCO 425) - LIQUID PROPANE TO VAPORIZER																			
284	2491	488	231.5	106.13	63.44	36.39	68.51	.389	1326	10.46	19.46	21.86	472	3.60	14.06	1799	90.18	73.0	.990	.27	6.07
			243.4					.371			186.5	3.16									5.78
		Y'D CARBURETOR (IMPCO 425) - LIQUID PROPANE TO VAPORIZER																			
285	2496	488	232.0	137.79	101.56	36.23	67.65	.399	1310	10.33	22.32	24.87	542	4.13	14.46	1852	92.52	72.1	1.019	-.13	6.23
			245.1					.377			214.0	2.72									5.90
		DIESEL ONLY																			
286	2509	464	221.7	137.82	89.05	48.77	91.07	.411	1763	13.90											6.27
			232.0					.393													5.99
		Y'D CARBURETOR (IMPCO 425)																			
287	2489	488	231.3	137.23	102.24	34.99	65.33	.389	1265	9.97	22.19	24.72	538	4.11	14.08	1804	90.06	71.7	1.023	-.18	6.09
			243.0					.371			212.7	2.64									5.79

FUEL DATA → DIESEL 28½ ¢/LITER, 19367 BTU/#, 863 KG/M³, PROPANE. 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE # - FT	BHP UNCORRECT (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # DIESEL # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT (CORRECTED)
		DIESEL ONLY																			
290	2182	448	182.2	134.73	93.65	41.07	76.70	.412	1485	11.71											6.29
			200.5					.383													5.84
		DIESEL ONLY																			
291	2208	456	191.7	133.18	91.34	41.64	78.14	.408	1513	11.93											6.22
			205.7					.380													5.80
		Y'D	CARBURETOR (IMPCO 425)																		
292	2202	464	194.5	139.26	109.66	29.60	55.27	.389	1070	8.43	18.31	20.40	444	3.39	11.82	1515	75.66	70.7	1.001	.10	6.08
			209.8					.362			175.5	2.71									5.65
		Y'D	CARBURETOR (IMPCO 425)																		
293	2204	460	193.1	142.66	113.43	29.24	54.60	.389	1057	8.33	18.35	20.44	445	3.40	11.73	1503	75.04	69.9	.993	.20	6.07
			207.7					.361			175.9	2.67									5.65
		Y'D	CARBURETOR (IMPCO 425) - WITHOUT CARB. AIR FILTER																		
294	2212	464	195.5	107.71	79.50	28.21	52.68	.393	1020	8.04	21.58	24.04	524	3.99	12.03	1544	76.72	67.4	1.021	-.11	6.16
			210.1					.364			206.9	2.19									5.71
		Y'D	CARB. (IMPCO 425) - NEW CARB. AIR FILTER - DIESEL FLOW ASSUMED SAME AS 294																		
295	2208	—	195.1	—	—	—	—	.391	—	—	21.28	23.70	516	3.94	11.96	1537	76.38	—	1.016	-.05	6.14
			210.3					.363			204.0	2.22									5.69
		Y'D	CARB. (IMPCO 425) - NEW CARB. AIR FILTER																		
296	2201	464	194.5	132.21	102.96	29.25	54.62	.385	1057	8.34	18.24	20.32	442	3.37	11.71	1500	74.94	69.9	.992	.21	6.02
			210.0					.357			174.9	2.69									5.58
		SAME AS 296																			
297	2211	460	193.7	138.04	109.09	28.96	54.07	.396	1047	8.25	20.25	22.55	491	3.75	12.00	1538	76.62	69.2	1.017	.07	6.19
			205.5					.367			194.1	2.40									5.75

FUEL DATA → DIESEL 28½ ¢/LITER, 19367 BTU/#, 863 KG/M³, PROPANE 18.5 ¢/LITER 21800 BTU/#

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP (UNCORRECT) (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR (UNCORRECT) (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR (# DIESEL / # PROPANE)	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR (UNCORR) (CORR)
		SAME AS 297																			
298	2208	464	195.1	136.32	108.11	28.81	53.79	.391	1041	8.21	20.14	22.43	489	3.73	11.94	1530	76.22	68.8	1.012	-.01	6.12
			209.8					.363			193.0	2.40									5.69
		SAME AS 297																			
299	2269	—	200.5	—	—	—	—	.384			20.86	23.23	506	3.86	12.07	1548	77.02	—	1.023	-.14	6.02
			215.6					.357			199.9	2.32									5.60
		SAME AS 297																			
300	2209	460	193.6	105.24	76.48	28.76	53.70	.387	1039	8.20	18.86	21.16	461	3.51	11.71	1501	74.86	65.7	.992	.22	6.05
			206.5					.363			182.1	2.54									5.67
		SAME AS 297																			
301	2207	460	193.4	137.45	103.62	33.83	63.17	.433	1223	9.64	18.39	20.49	446	3.40	3.05	1670	83.67	80.9	1.104	-1.12	6.75
			206.8					.405			176.3	3.08									6.31
		SAME AS 297																			
302	2213	456	192.2	135.58	106.51	29.08	54.29	.398	1051	8.29	19.96	22.24	484	3.69	11.98	1536	76.53	69.5	1.015	-.05	6.23
			205.4					.373			191.4	2.44									5.83
		SAME AS 297																			
303	2209	464	195.2	—	—	—	—	.387	—	—	19.07	21.24	463	3.53	11.81	1514	75.53	—	1.001	.11	6.05
			208.6					.362			182.8	2.56									5.66
		SAME AS 297																			
304	2210	452	190.2	—	—	—	—	.395	—	—	18.74	20.88	455	3.47	11.75	1506	75.17	—	.996	.17	6.18
			203.2					.370			179.7	2.60									5.78

FUEL DATA → DIESEL 28½ ¢/LITER, 19367 BTU/#, 863 KG/M³, PROPANE, 18½ ¢/LITER, 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # DIESEL + # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT CORRECT
		SAME AS 297																			
305	2210	456	191.9	133.81	104.56	29.25	54.61	.393	1057	8.34	18.73	20.87	454	3.47	11.80	1512	75.48	69.9	1.000	.13	6.15
			205.5					.367			179.6	2.62									5.74
		SAME AS 297																			
306	2210	456	191.9	109.77	80.78	28.99	54.13	.391	1048	8.26	18.74	20.87	455	3.47	11.73	1503	75.01	69.3	.994	.20	6.11
			205.5					.365			179.7	2.59									5.71
		SAME AS 297																			
307	2208	456	191.8	134.92	106.07	28.85	53.88	.390	1043	8.22	18.71	20.84	454	3.46	11.68	1497	74.72	69.0	.990	.24	6.09
			205.3					.364			179.4	2.59									5.69
		SAME AS 297																			
308	2203	456	191.3	136.07	107.00	29.07	54.29	.394	1051	8.29	18.89	21.04	458	3.49	11.78	1510	75.33	69.5	.998	.15	6.16
			206.6					.365			181.1	2.58									5.70
		SAME AS 297																			
309	2204	460	193.1	133.22	104.23	28.99	54.13	.389	1048	8.26	18.74	20.88	455	3.47	11.73	1503	75.01	69.3	.994	.20	6.08
			208.8					.359			179.7	2.59									5.62
		DIESEL ONLY																			
310	2203	460	193.0	111.27	69.44	41.84	78.12	.405	1512	11.92											6.18
			208.5					.375													5.72
		SAME AS 309																			
311	2193	460	192.1	109.69	77.35	32.35	60.40	.392	1169	9.22	13.41	14.94	325	2.48	11.70	1495	75.35	77.3	.989	.22	6.09
			207.1					.364			128.6	4.04									5.65

FUEL DATA → DIESEL 28½ ¢/LITER, 19396 BTU/#, 855 KG/M³, PROPANE. 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP (UNCORRECT) (CORRECT)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR (UNCORRECT) (CORRECT)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR ≡ DIESEL ≡ PROPANE	BTU/HR 1000X	COST $/HR	TOTAL FUEL COST $/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST $/HR	¢/BHP (UNCORR) (CORR)
	IMPCO 425			CARB. WITH ITS CLEANED FILTER							- PA ¼ TURN →				CLEANED MAIN FILTER, THROTTLE OI						
312	2198	500	209.3	134.96	90.95	44.01	82.18	.393	1594	12.54					(BUT STILL DIRTY)						5.9
			223.7					.367													5.6
	IMPCO 425			CARB. WITH ITS CLEANED				FILTER -			PA	CLOSED		→	CLEANED MAIN FILTER, THROTTLE						OPEN
313	1504	300	103.1	135.67	112.89	22.78	42.54	.413	825	6.49					(BUT STILL DIRTY)						6.3
			110.5					.385													5.8

FUEL DATA → DIESEL 28½ ¢/LITER, 19396 BTU/#, 855 KG/M³, PROPANE. 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR # DIESEL / # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT CORRECT.
	DIESEL ONLY, CLEAN MAIN FILTER																				
314	2198	0	0	130.53	122.43	8.10	15.12	—	293	2.31											—
			0					—													—
	DIESEL ONLY, CLEAN MAIN FILTER																				
315	2207	544	228.6	136.36	88.70	47.65	88.98	.389	1725	13.58											5.94
			240.9					.369													5.64
	IMPCO 425 CARB. + ITS FILTER, PA ¼ TURN, THROTTLE WIDE OPEN, CLEAN MAIN FILTER																				
316	2222	520	220.1	132.13	87.06	45.07	84.17	.389	1632	12.85	1.21	1.35	29	.22	13.07	1661	85.51	94.6	.963	.51	5.94
			232.6					.368			11.6	62.47									5.62
	IMPCO 425 CARB. + ITS FILTER, PA 5¼ TURNS, THROTTLE WIDE OPEN, CLEAN MAIN FILTER																				
317	2221	520	220.0	133.09	88.25	44.79	83.63	.386	1622	12.76	1.21	1.35	29	.22	12.99	1651	84.99	94.0	.957	.59	5.90
			233.5					.364			11.6	61.81									5.56
	IMPCO 425 CARB + ITS FILTER, PA ¼ TURN, THROTTLE WIDE OPEN, CLEAN MAIN FILTER																				
318	2198	0	0								0 ← WOULD NOT DRAW PROPANE										
			0																		

FUEL DATA → DIESEL 28½ ¢/LITER, 19396 BTU/#, 855 KG/M³, PROPANE. 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION						PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP (INDIRECT) (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR (INDIRECT) (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # DIESEL # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR (INDIRECT) (CORRECTED)
	DIESEL ONLY - CLEAN MAIN FILTER																			
318	2234	200	85.1	137.63	115.59	22.04	41.16	.484	798	6.28										7.38
			93.0					.443												6.75
	IMPCO 425 CARB. W/O ITS SPRING & FILTER, PA 5½ TURNS, THROTTLE WIDE OPEN, CLEAN MAIN FILTER																			
319	2199	208	87.1	136.04	115.67	20.37	38.04	.464	737	5.81	2.16	2.41	52	.40	6.21	790	40.4[illegible]	[illegible]	.990	.08	7.13
			95.2					.425			20.7	15.79								6.52
	DIESEL ONLY - CLEAN MAIN FILTER																			
320	2192	300	125.2	134.70	106.62	28.08	52.43	.419	1016	8.00										6.39
			137.3					.382												5.83
	SAME AS TEST 319																			
321	2219	300	126.8	134.20	108.16	26.09	48.63	.421	943	7.42	4.28	4.77	103	.79	8.21	1047	53.39	92.8	1.030	-.21	6.46
			138.8					.385			41.0	10.20								5.92
	SAME AS TEST 319																			
322	2199	544	227.8	132.62	90.85	41.77	77.99	.391	1512	11.90	9.90	11.02	240	1.83	13.73	1753	89.01	87.7	1.016	-.15	6.03
			241.1					.369			94.9	7.08								5.70
	SAME AS TEST 319																			
323	2197	544	227.6	—	—	—	—	.388	—	—	9.32	10.38	226	1.72	13.63	1739	88.38	87.7	1.008	-.05	5.99
			240.7					.367			89.4	7.51								5.66

FUEL DATA → DIESEL 28½ ¢/LITER, 19396 BTU/#, 855 KG/M³, PROPANE. 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECT)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECT)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # DIESEL # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT CORRECT
	DIESEL		ONLY	, MAIN	FILTER	CLEAN															
324	2209	400	168.2	115.21	79.09	36.13	67.46	.401	1308	10.30											6.12
			179.8					.375													5.73
	HOLLEY	2 BBL.	CARB.	RETOR	W/O	ITS	FILTER ,	CLEAN	MAIN	FILTER ,	PV		CLOSED ,	WIDE	OPEN	THROTTLE						
325	2211	400	168.5	117.73	86.75	30.98	57.85	.399	1122	8.83	8.38	9.33	203	1.55	10.38	1325	67.18	85.8	1.013	-.08	6.16
			181.4					.370			80.3	6.20									5.72
	DIESEL	ONLY	, DIRTY	MAIN	FILTER																
326	2203	400	167.8	119.28	82.68	3660	68.33	.407	1325	10.43											6.22
			162.5					.374													5.72
-	HOLLEY	2 BARREL	CARB	W/O	ITS	FILTER ,	DIRTY	MAIN	FILTER ,	PV	CLOSED ,	WIDE	OPEN	THROTTLE							
327	2216	400	168.8	116.98	94.52	22.46	41.95	.403	813	6.40	23.44	26.11	569	4.34	10.74	1382	68.06	61.4	1.043	-.31	6.36
			183.9					.370			224.7	1.61									5.84
-	REPEAT	OF	TEST	327																	
328	2219	400	169.0	—	—	—	—	.402	—	—	23.34	26.00	566	4.32	10.72	1380	67.95	61.4	1.042	-.29	6.34
			184.2					.369			223.8	1.61									5.82
-																					
	HALLEY	2 BBL.	CARB.	W/O	ITS	FILTER - PV	CLOSED ,	WIDE	OPEN	THROTTLE ,	CLEAN	MAIN	FILTER								
329	2206	400	168.1	118.01	86.84	31.17	58.20	.395	1128	8.88	7.43	8.28	180	1.37	10.26	1309	66.48	86.3	1.001	.04	6.10
			182.2					.365			71.3	7.03									5.63

FUEL DATA → DIESEL 28½ ¢/LITER, 19396 BTU/#, 855 KG/M³, PROPANE. 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FU COS
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECT)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECT)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # DIESEL # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BH
	COMPARE TO			TEST 324 - DAISEY DIESEL							BOOSTER (.128 # +15" WATER PRESS.) - CLEAN MAIN FILTER										
330	2187	400	166.6	117.73	85.74	31.99	59.73	.395	1158	9.12	5.39	6.00	130	1.00	10.11	1289	65.73	88.5	.986	.19	6.0
			180.2					.365			51.6	9.95									5.6
	COMPARE TO			TEST 326 - DAISEY DIESEL BOOSTED (.128 # +15" WATER PRESS.) - DIRTY MAIN FILTER																	
331	2199	400	167.5	119.82	87.45	32.37	60.44	.414	1172	9.22	8.01	8.92	194	1.48	10.71	1366	69.36	88.5	1.032	-.28	6.3
			182.1					.381			76.8	6.78									5.8
	COMPARE TO			TEST 326 - DAISEY DIESEL BOOSTER (.110 # +15" WATER PRESS.) - DIRTY MAIN FILTER																	
332	2207	400	168.1	120.74	87.53	33.21	62.01	.414	1202	9.46	6.83	7.60	165	1.26	10.73	1368	69.61	90.7	1.033	-.30	6.3
			182.2					.382			65.4	8.16									5.8
	COMPARE TO			TEST 260 - DAISEY DIESEL BOOSTER (.110 # +15" WATER PRESS.) - DIRTY MAIN FILTER - OPEN THROTTLE ON CARB. (WITH FIL																	
333	2383	300	136.1	119.57	91.78	27.80	51.90	.428	1006	7.92	5.77	6.43	140	1.07	8.99	1146	58.33	87.9	1.033	.03	6.6
			147.7					.395			55.3	8.07									6.0
	COMPARE TO			TEST 260 - DAISEY DIESEL BOOSTER (.110 # +15" WATER PRESS.) - CLEAN MAIN FILTER																	
334	2389	300	136.5	124.58	95.52	29.05	54.25	.434	1052	8.28	4.48	4.99	108	.83	9.11	1161	59.24	91.8	1.015	-.09	6.6
			146.1					.405			43.0	10.87									6.2
	COMPARE TO			TEST 324 - DAISEY DIESEL BOOSTER (.110 # +15" H_2O PRESS.) - CLEAN MAIN FILTER																	
335	2205	400	168.0	109.09	76.43	32.66	60.98	.391	1182	9.31	4.23	4.71	102	.78	10.09	1285	65.70	90.4	.983	.21	6.0
			181.1					.363			40.6	12.94									5.5

FUEL DATA → DIESEL 28½ ¢/LITER, 19396 BTU/#, 855 KG/M³, PROPANE, 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE FT-LB	BHP UNCORRECT / (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT / (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # DIESEL / # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT / CORRECT.
	DAISEY DIESEL			BOOSTER (.080 NOZZLE # 5 PSI) -							CLEAN MAIN FILTER				- COMPARE TO TEST 240						
336	2372	300	135.5	119.70	90.46	29.24	54.61	.435	1059	8.33	3.94	4.39	95	.73	9.06	1154	59.00	92.4	1.009	-.04	6.62
			145.0					.407			37.8	12.44									6.26
	DAISEY DIESEL BOOSTER (.080 NOZZLE # 5 PSI) - DIRTY MAIN FILTER - THROTTLE WIDE OPEN ON CARB. (WITH FILTER) - COMPARE TO TEST 266																				
337	2355	300	134.5	120.26	91.99	28.27	52.78	.426	1023	8.06	4.10	4.57	99	.76	8.81	1123	57.35	89.3	.982	.21	6.55
			144.7					.396			39.3	11.56									6.09
	REPEAT OF TEST 337 EXCEPT THROTTLE CLOSED ON CARB.																				
338	2374	300	135.6	119.98	91.73	28.25	52.75	.422	1023	8.05	4.06	4.52	98	.75	8.80	1121	57.27	89.3	.981	.22	6.49
			145.9					.392			38.9	11.67									6.03
	NOZZLE # 336, IMPCO MOD. VAPORIZER (ORANGE SPRING - ½" H_2O PRESS.), DIRTY MAIN FILTER, COMPARE TO TEST 240																				
339	2377	300	135.8	119.30	95.37	23.93	44.69	.447	866	6.82	14.34	15.98	348	2.65	9.47	1215	60.67	75.6	1.062	-.45	6.98
			146.1					.415			137.5	2.80									6.49
	SAME AS TEST 339 PLUS THROTTLE WIDE OPEN ON CARBURETOR (WITH FILTER)																				
340	2392	300	136.7	120.48	96.09	24.59	45.93	.427	890	7.01	11.20	12.48	272	2.07	9.08	1162	58.41	77.7	1.017	-.06	6.65
			147.0					.397			107.4	3.68									6.18
	SAME AS TEST 339 PLUS BALANCE LINE (VAPORIZER TO BOTT. OF MAIN FILTER)																				
341	2356	300	134.6	120.05	89.91	30.14	56.29	.442	1091	8.59	2.85	3.17	69	.53	9.12	1160	59.46	95.3	1.015	-.10	6.77
			144.8					.411			27.3	17.75									6.30

FUEL DATA → DIESEL 28½ ¢/LITER, 19396 BTU/#, 855 KG/M³, PROPANE, 18½ ¢/LITER, 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE	BHP (UNCORRECT) (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR (UNCORRECT) (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR # DIESEL # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR (UNCORR) (CORR)
	TO	#-FT																			
342	2388	300	136.5	121.15	92.25	28.90	53.97	.430	1046	8.24	4.18	4.65	101	.77	9.01	1148	58.62	91.3	1.004	.01	6.66
			145.5					.403			40.0	11.60									6.19
	SAME AS TEST # 342																				
343	2387	300	136.4	—	—	—	—	.427	—	—	3.77	4.20	91	.70	8.93	1138	58.16	91.3	.995	.09	6.55
			145.3					.400			36.1	12.86									6.15
	CHANGE TO TEST			260																	
	NOZZLE # 336, IMPCO MOD J VARORIZER (ORANGE SPRING - ½ H₂O WATER PRESS), CLEAN MAIN FILTER, BAL. LINE VARORIZER TO BOOT																				
344	2386	300	136.3	123.29	93.40	29.88	55.80	.434	1082	8.52	3.07	3.42	74	.57	9.08	1156	59.22	94.5	1.011	-.06	6.66
			145.8					.406			29.4	16.33									6.23
	SAME AS TEST # 344 EXCEPT NO BALANCE LINE USED																				
345	2393	300	136.7	104.79	75.91	28.88	53.93	.427	1046	8.23	4.00	4.46	97	.74	8.97	1143	58.39	91.3	.999	.05	6.56
			145.9					.400			38.4	12.10									6.15

FUEL DATA → DIESEL 28½ ¢/LITER, 19396 BTU/#, 855 KG/M³, PROPANE, 18½ ¢/LITER 21800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR # DIESEL / # PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT (CORRECTED)
		DIESEL ONLY - MAIN FILTER CLEAN - CARBURETOR THROTTLE CLOSED, BAL. LINE TO MAIN FILTER																			
346	2203	400	167.8	119.27	83.61	35.66	66.59	.397	1291	10.16											6.06
		DIESEL ONLY - CLEAN MAIN FILTER - CARB. THROTTLE CLOSED, BAL. LINE TO MAIN FILTER																			
347	2203	400	167.8	120.20	83.62	36.52	68.30	.407	1324	10.42											6.21
		Y'D CARBURETOR (HOLLEY 902) - BAL. LINE TO MAIN FILTER - BOTH FILTERS CLEAN																			
348	2214	400	168.7	122.72	88.06	34.65	64.71	.400	1255	9.83	2.51 (24.1)	2.80 (23.13)	60	.46	10.34	1316	67.51	94.7	.993	.08	6.13
		Y'D CARBURETOR (HOLLEY 902) - BAL. LINE TO BOTH FILTER - BOTH FILTERS CLEAN																			
349	2213	400	168.6	108.91	75.31	32.70	61.06	.389	1184	9.32	4.10 (39.3)	4.57 (13.37)	99	.76	10.08	1283	65.63	89.4	.969	.35	5.98

FUEL DATA → DIESEL 28.5 ¢/LITER, 19,396 BTU/#, 855 KG/M³, PROPANE. 18.5 ¢/LITER 21,800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT / (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR # Diesel / # Propane	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORR / (CORR)
	Y'D CARBURETOR - MAIN FILTER CLEAN - CARB. FILTER CLEAN - BAL. LINE TO BOTT. OF MAIN FILTER																				
350	2208	400	168.2	120.06	85.97	34.09	63.65	.394	1234	9.71	2.42	2.69	58	0.45	10.16	1293	66.34	93.2	.976	.26	6.0
			180.1					.368			23.2	23.63									5.6
	SAME AS TEST 350																				
351	2125	400	161.9	—	—	—	—	.406	—	—	1.82	2.03	44	0.34	10.05	1278	65.68	93.2	.965	.37	6.2
			173.9					.378			17.5	31.31									5.7
	Y'D CARBURETOR - MAIN FILTER CLEAN - CARB. FILTER CLEAN - BAL. LINE TO BOTT. OF BOTH FILTERS																				
352	2201	400	167.7	120.74	87.99	32.74	61.14	.393	1185	9.33	4.23	4.72	102	0.78	10.12	1288	65.86	89.5	.973	.31	6.0
			180.1					.366			40.6	12.97									5.6
	SAME AS TEST 352																				
353	2192	400	167.0	—	—	—	—	.391	—	—	3.69	4.11	89	0.68	10.01	1275	65.25	89.5	.963	.41	6.0
			179.2					.364			35.4	14.88									5.5
	Y'D CARBURETOR - MAIN FILTER CLEAN - CARB. FILTER CLEAN - BAL. LINE TO CARBURETOR FILTER																				
354	2208	400	168.2	119.95	87.38	32.57	60.81	.396	1179	9.28	5.13	5.72	124	0.95	10.23	1304	66.53	89.0	.985	.19	6.0
			181.0					.368			49.2	10.64									5.6
	SAME AS TEST 354																				
355	2198	400	167.4	—	—	—	—	.394	—	—	4.58	5.11	111	0.85	10.13	1290	65.92	89.0	.974	.29	6.0
			180.2					.366			43.9	11.91									5.6
	SAME AS TEST 354																				
356	2196	400	167.3	—	—	—	—	—	—	—	—	5.10	—	—	—	—	65.91	—	—	.30	—
			180.1					—			—	11.92									—

FUEL DATA → DIESEL 28.5 ¢/LITER, 19,396 BTU/#, 855 KG/M³, PROPANE. 18.5 ¢/LITER 21,800 BTU/#

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR # Diesel #Propane	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-H UNCORRECT. (CORRECTED)
	Y'D	CARBURETOR - MAIN FILTER DIRTY - CARBURETOR FILTER CLEAN																			
358	2195	400	167.2	122.60	94.39	28.21	52.67	.399	1021	8.04	12.55	13.98	304	2.32	10.36	1326	66.65	77.1	1.001	.06	6.20
			180.4					.369			120.3	3.77									5.74
	Y'D	CARBURETOR - BOTH FILTERS DIRTY																			
359	2189	400	166.7	121.87	91.17	30.70	57.33	.427	1112	8.75	12.45	13.87	302	2.30	11.05	1414	71.21	83.9	1.068	-.63	6.63
			179.6					.396			119.4	4.13									6.16
	Y'D	CARBURETOR - MAIN FILTER DIRTY - CARBURETOR FILTER CLEAN - BAL. LINE TO BOTT. OF BOTH FILTERS																			
360	2200	400	167.6	119.47	92.57	26.90	50.23	.395	974	7.67	14.39	16.04	349	2.66	10.33	1323	66.26	73.5	.999	.10	6.16
			180.6					.367			138	3.13									5.72
	Y'D	CARBURETOR - MAIN FILTER DIRTY - CARBURETOR FILTER DIRTY - BAL. LINE TO BOTT. OF BOTH FILTERS																			
361	2200	400	167.6	120.23	91.22	29.02	54.18	.401	1050	8.27	11.68	13.01	283	2.16	10.43	1334	67.19	79.3	1.007	-.01	6.22
			180.5					.372			112	4.16									5.78
	Y'D	CARBURETOR - MAIN FILTER DIRTY - CARBURETOR FILTER CLEAN - BAL. LINE TO BOTT OF MAIN FILTER																			
362	2191	400	166.9	105.36	77.35	28.02	52.32	.402	1014	7.99	13.22	14.73	321	2.45	10.43	1335	67.04	76.6	1.008	-.01	6.25
			180.3					.372			126.7	3.55									5.79
		SAME AS TEST 362																			
363	2197	400	167.4	119.71	90.71	29.00	54.15	.399	1050	8.26	11.35	12.65	275	2.10	10.36	1325	66.79	79.3	1.001	.06	6.19
			180.3					.370			108.8	4.28									5.75

FUEL DATA → DIESEL 28.6 ¢/LITER, 19,396 BTU/#, 855 KG/M³, PROPANE 18.5 ¢/LITER 21,800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP (INCORRECT) (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR (UNCORRECT) (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR #DIESEL/#PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR (UNCORRECTED) (CORRECTED)
	OPEN END TUBE - CLEAN FILTERS - MODEL J VAPORIZER																				
364	2205	400	168.0	119.80	85.06	34.74	64.87	.401	1258	9.90	2.26	2.51	54	.42	10.32	1313	67.38	95.0	.991	.11	6.14
			178.9					.377			21.6	25.80									5.7
	OPEN END TUBE - CLEAN FILTERS - MODEL T VAPORIZER																				
365	2210	400	168.4	120.61	85.77	34.84	65.05	.399	1261	9.93	1.89	2.11	45	.35	10.28	1307	67.16	95.2	.987	.15	6.1
			178.4					.376			18.1	30.88									5.7
	OPEN END TUBE - CLEAN FILTERS - MODEL T VAPORIZER - LIQUID PROPANE FEED																				
366	2205	400	168.0	121.57	86.72	34.85	65.07	.401	1262	9.93	2.01	2.24	48	.37	10.30	1310	67.31	95.3	.990	.12	6.1
			179.6					.375			19.2	29.10									5.7
	5X4 VENTURI (DIRECTLY IN) - CLEAN MAIN FILTER - BAL. LINE (THINK RPM WAS 2200 - COUNTER OFF ?)																				
367	1910	400	145.5	120.44	0..87	34.57	64.56	.464	1252	9.85	2.57	2.69	62	.48	10.33	1315	67.45	94.5	.993	.09	7.10
	?.		157.3					.429			24.9	22.36									6.57
	5X4 VENTURI (DIRECTLY IN) - CLEAN MAIN FILTER - BAL. LINE (THINK RPM WAS 2200 - COUNTER OFF ?)																				
368	1907	400	145.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7.11
	?.		157.0					—			24.8	—									6.56
	5X4 VENTURI (SLOPED END TUBE) - CLEAN MAIN FILTER - BAL. LINE (THINK RPM WAS 2200 - COUNTER OFF																				
369	1925	400	146.7	120.53	86.64	33.89	63.27	.458	1227	9.66	3.48	3.87	84	.64	10.30	1311	67.15	92.6	.990	.12	7.02
	?.		159.1					.422			33.3	16.34									6.4

NOTE! DAISEY METERING VALVE USED IN ALL TESTS

FUEL DATA → DIESEL 28.5 ¢/LITER, 19,396 BTU/#, 855 KG/M³, PROPANE 18.5 ¢/LITER 21,800 BTU/#

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT / (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT / (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR #DIESEL / #PROPANE	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-H UNCORRECTED / CORRECTED
	5X3 VENTURI (SLOPED END TUBE) - CLEAN MAIN FILTER - BAL. LINE - DAISEY METERING VALVE																				
370	2208	400	168.2	119.59	89.77	29.82	55.69	.398	1080	850	10.12	11.28	245	1.87	10.37	1326	66.37	84.5	1.001	.05	6.17
			179.8					.372			97.1	4.94									5.77
	SAME AS TEST 370																				
371	2203	400	167.8	119.10	89.53	29.57	55.23	.396	1071	8.43	10.10	11.25	245	1.87	10.30	1316	66.47	80.9	.994	.13	6.13
			180.7					.368			56.5	4.91									5.70
	5X3 VENTURI (DIRECTLY IN) - CLEAN MAIN FILTER - BAL. LINE - DAISEY METERING VALVE																				
372	2210	400	168.3	119.80	88.04	31.76	59.31	.398	1150	9.05	6.88	7.66	167	1.27	10.32	1317	66.97	86.8	.994	.10	6.13
			181.5					.369			65.9	7.74									5.69
	SAME AS TEST 372																				
373	2202	400	167.7	120.03	88.63	31.40	58.64	.401	1137	9.95	7.76	8.65	188	1.44	10.39	1325	67.28	85.8	1.001	.04	6.19
			181.6					.370			74.4	6.78									5.72
	EX3 VENTURI (DIRECTLY IN) - CLEAN MAIN FILTER - BAL. LINE - NO DAISEY METERING VALVE																				
374	2211	400	168.4	160.73	76.33	24.39	45.55	.395	893	6.95	18.81	20.96	456	3.48	10.43	1340	66.51	56.7	1.012	.01	6.20
			176.7					.376			180.9	2.17									5.90
	SAME AS TEST 374																				
375	2209	400	168.3	—	—	—	—	—	—	—	18.76	20.90	455	3.47	10.42	1339	66.45	66.7	1.011	.00	6.19
			176.6					—			179.9	2.18									5.90

FUEL DATA → DIESEL 28.5 ¢/LITER, 19,396 BTU/#, 855 KG/M³, PROPANE 18.5 ¢/LITER 21,800 BTU/#

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP UNCORRECT (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (ft³/HR)	#/HR # Diesel # Propane	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORR. CORR.
	5X4 VENTURI (DIRECTLY IN) - CLEAN FILTER - BAL. LINE																				
376	2200	400	167.6	112.88	83.56	29.32	54.76	.398	1062	8.36	10.66	11.87	258	1.97	10.33	1320	66.63	80.2	.997	.10	6.16
			180.4					.369			102.2	4.61									5.72
	5X4 VENTURI ("R" SLOPED END METERING TUBE) - CLEAN FILTER - BAL. LINE																				
377	2205	400	168.0	117.26	86.38	30.88	57.67	.401	1118	8.80	8.70	9.69	211	1.61	10.41	1329	67.36	84.4	1.004	.01	6.20
			180.1					.374			83.4	5.95									5.78
	SAME AS TEST 377 EXCEPT DIRTY FILTER USED																				
378	2186	400	166.5	119.23	86.98	32.25	60.22	.425	1167	9.19	9.48	10.56	230	1.75	10.94	1398	70.78	88.2	1.055	-.52	6.51
			178.4					.397			90.9	5.70									6.14
	5" STRAIGHT TUBE (SLOPED END METERING TUBE) - CLEAN FILTER - BAL LINE																				
379	2205	400	167.9	120.17	85.73	34.44	64.32	.401	1247	9.82	2.77	3.09	67	.51	10.33	1314	67.40	94.2	.992	.10	6.15
			179.7					.375			26.6	20.84									5.75
	5X4 VENTURI (DIRECTLY IN - NO TUBE) - CLEAN FILTER - BAL. LINE																				
380	2156	148	60.8	118.34	90.59	27.76	51.83	.946	1005	7.91	5.06	5.64	122	.94	8.85	1128	57.47				14.56
			64.6					.889			48.5	9.20									13.69
	SAME AS TEST 380																				
381	2158	100	41.1	117.15	103.23	13.91	25.98	.664	503	3.97	1.17	1.30	28	.22	4.18	532	27.28	83.4	.877	.57	10.18
			43.7					.624			11.2	19.93									9.57
	NOTE: NO DAISEY METERING VALVE USED																				

FUEL DATA → DIESEL 28.5 ¢/LITER, 19,396 BTU/#, 855 KG/M³, PROPANE, 18.5 ¢/LITER 21,800 BTU/#.

TEST NO.	ENGINE LOAD			DIESEL CONSUMPTION							PROPANE CONSUMPTION				DIESEL & PROPANE			DIESEL-PROPANE/DIESEL			FUEL COST
	RPM	TORQUE #-FT	BHP INCORRECT (CORRECTED)	SUPPLY L/HR	RETURN L/HR	NET L/HR	NET #/HR	#/BHP-HR UNCORRECT (CORRECTED)	NET (1000) BTU/HR	COST ¢/HR	L/HR (FT³/HR)	#/HR #Diesel #Propane	BTU/HR 1000X	COST ¢/HR	TOTAL FUEL COST ¢/HR	TOTAL BTU/HR (1000)	TOTAL #/HR	% DIESEL	RATIO OF BTU'S	SAVINGS IN FUEL COST ¢/HR	¢/BHP-HR UNCORRECT CORRECT
	5X3 VENTURI (NO METERING TUBE) - CLEAN FILTER - BAK. LINE																				
383	1156	40	8.8	103.42	99.32	4.10	7.66	1,095	148	1.17	1.78	1.98	43	.33	1.50	191	9.64				17.01
			9.3					1.036			17.0	3.88									16.10
	SAME AS TEST 383																				
384	1160	100	22.1	85.39	79.37	6.02	11.24	.628	218	1.72	2.36	2.63	57	.44	2.15	275	13.88	75.6	.350	.12	9.75
			23.4					.594			22.7	4.27									9.22
	SAME AS TEST 383																				
385	—	—	—	104.59	99.10	5.49	10.25	.583	198	1.56	—	—	—	—	2.00	256	12.89	69.0	.884	.27	9.06
			—					.552			—	3.90									8.57
	SAME AS TEST 383 EXCEPT NO PROPANE METER USED																				
386	1176	100	22.4	105.97	99.57	5.49	10.25	.458	198	1.57											
			23.7					.432													
	SAME AS TEST 386																				
387	—	100	—	104.87	99.13	5.74	10.71	.478	207	1.63											
			—					.452													
	NOTE 1 NO DAISEY METERING VALVE USED																				